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IS TECHNOLOGY A COMPLEMENT OR SUBSTITUTE TO REFEREEING IN SPORTS? A REVIEW

(Review study)

Aryan Goel [a]

[a] *India*

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Abstract

The objective of this review article is to conduct a comprehensive analysis of the incorporation of technology in the field of sports officiating, specifically emphasising its use in the context of football refereeing. The review finds that the adoption of technology in sports officiating has significantly enhanced decision-making accuracy and fairness. Technologies such as VAR in football have been effective in reducing home advantage bias and increasing decision accuracy. However, these technologies also pose challenges, including disruptions to the flow of the game and varying levels of acceptance among coaches, fans and players. The paper also discusses the economic and audience engagement aspects influenced by the utilisation of technology in sports. The findings of this review have critical implications for sports governing bodies, referees, players, and fans. They provide insights into the balance between maintaining the traditional essence of sports and embracing technological advancements. The review also highlights the need for consistent application and transparent communication regarding the usage of technology in sports. This review paper offers a comprehensive collation and analysis of research on the usage of technology in sports officiating, providing a global perspective on its effectiveness and challenges. It contributes to academic discourse and practical understanding, guiding future developments in sports officiating and policy-making.

Keywords: Sports Technology, Refereeing, Video Assistant Referee (VAR), Decision Accuracy, Hawk-Eye.

*Corresponding author: Aryan Goel. ORCID ID.: https://orcid.org/ 0000-0001-6569-0301 E-mail: aryan170307@gmail.com

1. Introduction

Refereeing in sports serves as the cornerstone of fairness, integrity, and the orderly conduct of games. It encompasses the enforcement of rules, making critical decisions, and ensuring a level playing field, thereby safeguarding the spirit of competition. The importance of referees in sports cannot be overstated, as their decisions directly impact the outcome of games, influence player behaviour, and uphold the standards of the sport.

Football, being the world's most popular sport, showcases the extensive scope of refereeing. With millions of referees officiating in various leagues and competitions across the globe, the scale of football refereeing is immense. Annually, countless football matches are played, drawing in vast audiences both in stadiums and through media broadcasts. The economic impact of football is equally significant, with substantial revenues generated from ticket sales, broadcasting rights, sponsorships, and merchandising. This financial aspect underscores the crucial role of referees in maintaining the integrity and appeal of the sport.

The growing trend of using technology to complement or substitute human referees marks a transformative phase in sports. Technologies like the Video Assistant Referee (VAR) in football, Hawk-Eye in tennis and cricket, and instant replay systems in American football and basketball, are becoming integral to officiating. This shift towards technology is not just a response to increasing demands for accuracy and fairness but also reflects the evolution of sports in the digital age.

The integration of technology in refereeing is poised to change the sport significantly. It promises to reduce human error, ensure more consistent and fair decisions, and potentially reshape the strategies and dynamics of games. However, this transition also brings challenges, such as maintaining the flow of the game, balancing technology with human judgment, and addressing the concerns of players, coaches, and fans. Despite the widespread implementation of refereeing technologies, there is a noticeable gap in the comprehensive collation and analysis of research on this subject. Various studies across countries have examined the impact of technology in refereeing, focusing on aspects like decision accuracy, bias reduction, and the influence on game dynamics. However, a consolidated review of such research is lacking.

This review paper aims to fill this gap by providing a comprehensive analysis of existing studies on the use of technology in sports officiating. It seeks to collate findings from diverse geographical and sporting contexts, offering a global perspective on the effectiveness, challenges, and implications

of technological integration in refereeing. By doing so, the paper will not only contribute to academic discourse but also provide insights for sports governing bodies, referees, players, and fans. This review will aid in understanding the broader impacts of technology on sports, guiding future developments in officiating and ensuring that the evolution of sports remains true to its essence – a celebration of fair play, competition, and human excellence.

2. Method

Collection of Data

Our study examines technological developments and innovations in football. Literature sources were scanned to examine the evaluation. Qualitative research method was used as the method and mainly subject-specific articles were published. studies and internet research were conducted.

Data Collection Tool

In this study created with the traditional compilation method; These topics were examined and evaluated in Pub Med, Google Scholar and Web's Science databases using the keywords Sports Technology, Refereeing, Video Assistant Referee (VAR), Decision Accuracy, Hawk Eye. It is based on studies conducted in the literature.

3. Results and Discussion

The Concept and Evolution of Refereeing

Refereeing is a crucial component across various sports to ensure fair play and adherence to the rules of the game. The role of referees has evolved over time with the growth of professional sports leagues and advancements in technology. This literature review provides an overview of the history and evolution of refereeing across major sports like football (soccer), American football, basketball, cricket, and more recently, the integration of technology like the Video Assistant Referee (VAR) system. Organized sports first emerged in England during the 19th century, with documented evidence of referee use in football as early as 1835 (Kitching, 2015).

However, the concept of an adjudicator or umpire has been around in various forms much earlier in sporting history. By the early 20th century, dedicated referee roles were established across most major sports to officiate matches. Their importance arose from the need for impartial decision-making and preventing conflicts during competitive games (Simmons & Cunningham, 2013).

Today, referees are indispensable for regulating play, enforcing rules, controlling player conduct, and facilitating safety across sports. Referees have since become a staple in a wide range of sports, including football, basketball, tennis, and many others, each with unique rules and requirements for officiating. The history and evolution of refereeing in sports present a dynamic and multifaceted narrative, reflecting changes in technology, societal attitudes, and the sports themselves. The role of referees, integral to ensuring fairness and adherence to rules, has evolved significantly from its inception to the present day. The impact of contentious referee decisions on game outcomes is significant. Consequently, football has recently initiated a process of modernization aimed at enhancing the game's quality and fairness. These changes, which involve the integration of new technologies, have been long overdue in comparison to the digital transformation observed in other sports, particularly in light of the rapid advancements in Internet of Things (IoT) and Artificial Intelligence (AI). In football, the referee's role is pivotal in maintaining the flow of the game, enforcing rules, and making critical decisions that can influence the outcome of a match. This is echoed in basketball and tennis, where referees and umpires play similar roles in ensuring fair play and adherence to the sport's regulations (Huggins, 2023). The importance of referees in these sports cannot be overstated. The individuals in question bear the responsibility of interpreting and implementing the regulations, overseeing the participants and the game, and guaranteeing the security and credibility of the athletic activity. Their decisions can have significant emotional impacts on players and fans alike (Yildiz, 2022). An interesting aspect of refereeing in sports is the influence of social factors on decision-making. Garicano et al., (2001) it has been noted that referees exhibit a bias towards the home side by granting additional stoppage time when the home team is trailing, indicating a latent inclination towards seeking social validation from the home crowd. Several researchers have identified key competencies required in referees across sports. These include expertise in the laws of respective games, aerobic fitness to keep up with gameplay, visual-cognitive skills for decision-making accuracy, effective communication and game management abilities (Helsen et al., 2022; Barghi et al., 2021; Weston et al., 2004).

Additionally, being impartial with emotional regulation skills and displaying leadership qualities are vital for earning players' respect (Kitching, 2015). In football, for example, the physical demands on referees are significant, requiring high levels of cardiorespiratory fitness and body composition (Asian Journal of Sports Medicine, 2016). In contrast, sports like tennis may place a higher emphasis on visual skills and the ability to make split-second decisions (Barghi et al., 2021). Furthermore, referees' decisions are often affected by various external factors, such as crowd noise, fan pressure, and the match's location. These factors can lead to perceptual limitations and biases in decision-making (Unkelbach and Memmert, 2010; Goumas, 2014). To mitigate these biases, technical officiating aids like VAR have been gradually introduced, significantly improving the accuracy of refereeing decisions (FIFA, 2018).

Referees serve a tough position and are constantly scrutinised since everyone expects them to make perfect calls. Players, coaches, the media, and the public frequently subject them to criticism and societal pressure. (Johansen, 2015). Standardized training programs, technological aids, and performance evaluation systems have improved refereeing over the years across sports. Introduction of professional referee organizations attempted to enhance consistency and enabled merit-based referee selections for important games (Abdullah, 2015). Recent decades have accelerated technology integration to optimize officiating, such as goal line technology in football and the NBA challenge system for contested calls (Vale, 2022). Most impactfully, VAR has been incorporated across several sports since 2018 to allow video reviews and overturning erroneous decisions by on-field referees. Despite technology minimizing human errors, referees continue to control games and facilitate player relationships. Their training has focused on effectively utilizing technological aids (Yildiz, 2022). Overall, the evolution of refereeing in sports reflects a balance between tradition and innovation, where the fundamental goal remains to uphold the spirit and integrity of the game while adapting to changing times and technologies. The journey of referees, from the early days of sports to the modern era of advanced technology, highlights their indispensable role in the world of sports (Helsen et al., 2022; Abdullah, 2015).

Technology in Sports

Recent decades have witnessed massive growth in the incorporation of technology across various in-game facets of sports to optimize performance analysis, training simulations, injury prevention, and officiating accuracy (Frevel et al., 2022). The Big Data era includes sports because large volumes

of data are being collected and evaluated to give athletes real-time competitive advantages throughout competitions, practise, preparation, and recruitment (Pires & Santos, 2018).

Some major areas that utilize advanced technologies are discussed below:

Performance Analysis

Detailed quantification of player movements, techniques, and strategies are extracted from video feeds using specialized software to provide invaluable performance insights (Frevel et al., 2022). Analytics helps athletes tailor training, coaches design tactical approaches, and teams scout opponents more effectively. Technologies like player tracking, skill markers, and advanced metrics are prominently used in sports like football, basketball, baseball, and tennis.

Officiating Aids

As discussed in the previous section, refereeing aids like VAR, goalline technology in football, ball tracking in tennis, and the decision review system in cricket have enhanced officiating accuracy in recent years (Vale, 2022). VAR is a three-person team that reviews controversial on-pitch referee decisions. While concerns exist on gameplay interruptions, evidence largely suggests improved decision-making without affecting match dynamics (Kim et al., 2022; Meneguite et al., 2022). Automated calls also reduce human errors for close judgment situations across sports.

Simulations and Virtual Reality

Simulating game scenarios through software and virtual reality environments provide experiential learning for athletes without physical exertion requirements or injury risks during real practice (Frevel et al., 2022). These technologies enable customized simulations for techniques and tactics across sports like football, basketball, and baseball by generating a broad range of situations.

Athlete Tracking and Monitoring

Wearables like GPS trackers, heart rate monitors, and body sensors allow detailed quantification and monitoring of key athletic indicators related to workload, conditioning, fatigue, technique, rehabilitation status, and injury risks (Weston et al., 2004). This data further aids coaching decisions and medical interventions when issues arise. Such technologies have permeated across most professional team sports and endurance athletics over the past decade.

Technology Used to Complement or Substitute Referees

The evolution of technology in sports has led to significant advancements in the way games are officiated. Across various sports, technology is increasingly being used either to complement or, in some cases, substitute human referees. This trend reflects a broader effort to enhance accuracy, fairness, and objectivity in sports officiating. Football (Soccer): The Video Assistant Referee (VAR) system, now a staple in football, exemplifies the use of technology to assist referees. VAR reviews decisions made by the on-field referee for critical incidents such as penalties, goals, and red card offenses. This technology has been instrumental in reducing errors and enhancing decision accuracy in football matches (FIFA, 2021; International Football Association Board, 2020). Tennis: The Hawk-Eye system is employed in tennis to impartially ascertain whether the ball has contacted or departed from the court. This technology offers a high level of precision in making line calls, which are often challenging for human eyes to judge accurately (Collins and Evans, 2012). Cricket: Similar to tennis, cricket employs the Hawk-Eye system for the Leg Before Wicket (LBW) decisions and for tracking the trajectory of the ball. Additionally, the Decision Review System (DRS) allows players to challenge the umpire's decision, which is then reviewed using technology like Hawk-Eye, UltraEdge, and ball tracking (Tamir and Bar-Eli, 2021). American Football: In the National Football League (NFL), instant replay technology is used to review various plays and officiating decisions. Coaches can challenge certain on-field decisions, which are then reviewed through video replay to ensure accuracy (Vannatta, 2011). Basketball: The National Basketball Association (NBA) has implemented the Replay Center, which uses video technology to assist referees in making more accurate decisions. The Replay Center can be used for game-clock malfunctions, out-of-bounds calls, and to determine if a shot was released before the shot clock or game clock expired (Chandler, 2021). Rugby: In rugby, the Television Match Official (TMO) system is used. The TMO assists the on-field referee in making decisions related to the scoring of tries, foul play, and other key aspects of the game. The TMO has access to multiple camera angles and replays to inform their decisions (Collins and Evans, 2012). Ice Hockey: The National Hockey League (NHL) uses video replay and a Situation Room to review goals, potential offsides, and goalie interference. This system helps in making critical game-changing decisions with greater accuracy (Kolbinger and Lames, 2017). Baseball: Major League Baseball (MLB) utilizes the replay review system where umpires can review calls on home runs, foul balls, and other critical plays. This system allows for the correction of missed or erroneous on-field calls (Kolbinger and Link, 2016). The integration of technology in sports officiating, as seen across these various sports, is not without challenges and controversies. Concerns have been raised about the impact of technology on the flow and spirit of games, the potential for over-reliance on technology, and the need for clarity and consistency in its application (Nlandu, 2012; Svantesson, 2014).

However, the overall trend suggests that technology, when used effectively, can significantly enhance the fairness and integrity of sports competitions. As sports continue to evolve, the role of technology in officiating is likely to grow and become more sophisticated. The balance between human judgment and technological assistance remains a critical aspect of this evolution, ensuring that the spirit of sportsmanship and the integrity of games are upheld.

Measuring Efficacy of Using Technology

Video Assistant Referee (VAR) is a system designed to aid referees in making critical decisions during a match. Virtual Assistant Referee (VAR) functions within a Video Operation Room (VOR) and autonomously evaluates decisions pertaining penalties, direct red cards, goals and mistaken identities (International Football Association Board, 2020). This technology, similar in function to systems used in tennis, basketball, and American football, exemplifies the growing reliance on technological aids in sports. The protocol requires the VAR and replay operator to review all match-changing video feeds and replays. If a check shows an obvious error by the referee or assistant referee, the VAR advises revising the previous judgement. VAR information could change a factual conclusion, such an offside before a goal known as a VAR-only review. Before awarding subjective decisions such as red cards (onfield review), the main referee can examine footage shown on a monitor in close proximity to the field (Spitz et al., 2021). Technology has the potential to enhance decision-making in both temporal (specific time) and spatial (location of the ball, player) situations (Carboch et al., 2016). VAR in football has been a subject of much debate, affecting not only the decision-making process but also the emotional dynamics of the sport (Meneguite et al., 2022; Kim et al., 2022). The impact of such technologies varies across different sports, with each sport adapting to technological advancements in its own way (Frevel et al., 2022; Duz et al., 2022).

Negative Impact

Studies have shown that VAR can negatively impact the sentiment of spectators, especially those of the English Premier League (Kolbinger & Knopp, 2020). Football managers have also been known to question VAR decisions, particularly when they disadvantage their team. The role of the referee, always complex, has been further complicated by these technological advancements (Johansen, 2015). Referees, under intense scrutiny, must balance the expectations of flawless decision-making with the pressure exerted by players, coaches, media, and the public. In women's football, the introduction of VAR at the 2019 FIFA Women's World Cup demonstrated a noteworthy increase in match duration, reflecting a trend observed in men's football (Zhang et al., 2022). Some football VAR

detractors say interrupting play to review film of contested situations breaks the flow of the match and reduces its tempo (Svantesson, 2014; Nlandu, 2012; Scanlon et al., 2022).

Positive Impact

Evidence suggests improved decision accuracy and no detrimental gameplay effects from most sports studied so far (Meneguite et al., 2022; Duz et al., 2022). VAR's influence extends beyond mere decision-making accuracy. It has been implicated in altering the dynamics of games, affecting the number of fouls and yellow cards, and influencing player behavior (Lago-Peñas, Rey & Kalén, 2019). Despite initial concerns that VAR might disrupt the natural flow of football, studies have shown that its impact on game duration is relatively minimal (Oliveira et al., 2020). Technical officiating aids like VAR can help improve the accuracy of refereeing decisions (FIFA, 2018) by reducing perceptual limitations and biases in decision-making (Unkelbach and Memmert, 2010; Goumas, 2014). VAR changes matches in penalties, red cards, goals, and misidentification (Chandler, 2021; FIFA, 2021).

Video Assistant Referee (VAR) minimises substantial errors and enhances the precision of officiating in intricate and ever-changing football matches. According to FIFA (2018), the officiating accuracy in the 2018 Men's World Cup was 95.60% without VAR and 99.35% with it. With VAR, first-half and game-long additional time has increased. The use of this technology resulted in fewer fouls and yellow cards, as well as improved player control over aggressive fouls (Lago-Peñas, Rey & Kalén, 2019). VAR reduces football doubts, as is generally recognised. The sport's evolution has reduced uncertainty in the Premier League® (first division of the English Soccer Championship) over the past 50 years (Haugen, 2019).

Thus, VAR reduces playing field uncertainty even more. VAR influence, as in the 2019 Brazilian Championship, can affect football dynamics. Research suggests that applying VAR does not significantly lengthen football matches, supporting earlier researches (Lago-Peñas et al., 2020; Errekagorri et al., 2020;). During the FIFA Women's World Cup, the use of VAR resulted in a addition of only one minute in the first half (46.12 min without VAR compared to 47.37 min with VAR) and the second half (48.42 min compared to 49.46 min), respectively. Additionally, VAR added two minutes to the total duration of the match. Thus, modern sports have deeply integrated a variety of technologies related to analytics, officiating, simulations and tracking for optimizing athlete performance, accuracy, safety, tactics, and operational decisions. While human skills remain essential, technological innovations have provided more informed inputs. Further research must balance these benefits with retaining gameplay quality and reasonable interruptions. Overall, the use of technology in sports, particularly in officiating, has become increasingly important. Technologies

like VAR, Hawk-Eye, and wearable tech have not only enhanced the accuracy and fairness of sports competitions but also brought new dimensions to the analysis and understanding of sports performance. The continuous evolution of these technologies suggests a future where their integration into sports will become even more sophisticated and impactful.

Efficacy of Using Technology to Complement or Substitute Human Referees

The usage of technology in sports officiating has become highly prevalent, offering a blend of human judgment and technological precision. Various studies have explored the efficacy of these technologies in reducing referee bias and improving decision accuracy. Football (Soccer): The Video Assistant Referee (VAR) system has significantly altered the dynamics of football refereeing. A study by Kim, Chang yuan, Kyung Yul, and Young Son found that the introduction of VAR in professional football leagues resulted in a rise in the average number of goals scored by the teams, suggesting a decrease in the bias towards home advantage that is often affected by referees (Kim et al., 2022). Furthermore, VAR has improved decision-making accuracy from 92.1% to 98.3% (Spitz et al., 2020). However, the technology has faced criticism for interrupting the flow of the game and allegedly favoring certain teams during the 2018 FIFA World Cup (Kolbinger & Knopp, 2020). Tennis: The Hawk-Eye system in tennis has been effective in providing accurate line calls, thereby reducing the pressure on on-court officials and minimizing biased judgments in closely contested matches (Collins and Evans, 2012). Cricket: Similar to VAR in football, cricket's Decision Review System (DRS) utilizes technology like Hawk-Eye and UltraEdge to assist umpires in making more accurate decisions. This system has enhanced the accuracy of critical decisions like LBW (Leg Before Wicket) while preserving the essential roles of umpires in interpreting complex laws of the game (Tamir and Bar-Eli, 2021). American Football: The National Football League (NFL) utilizes instant replay technology, allowing coaches to challenge certain on-field decisions. This has contributed to the accuracy of crucial game decisions (Vannatta, 2011). Basketball: The NBA's Replay Center supports referees in making accurate decisions, particularly in situations involving game-clock malfunctions and boundary calls. This technique facilitates the preservation of the game's integrity while guaranteeing equitable competition. (Chandler, 2021). Rugby: Rugby's Television Match Official (TMO) system aids on-field referees in decision-making related to scoring and foul play. Access to multiple camera angles and replays provides a more comprehensive view for accurate decisions (Collins and Evans, 2012). Ice Hockey: The NHL employs video replay and a Situation Room to assist in decision-making on goals, offsides, and goalie interference, enhancing the accuracy of critical game decisions (Kolbinger and Lames, 2017). Baseball: MLB's use of replay review systems allows umpires to correct missed or erroneous calls on critical plays, such as home runs and foul balls

(Kolbinger and Link, 2016). Despite these advancements, challenges remain, particularly regarding the impact of technology on the flow and spirit of games. Concerns about over-reliance on technology and the need for consistency in its application persist (Nlandu, 2012; Svantesson, 2014). In conclusion, while technology has significantly enhanced the accuracy and fairness of sports officiating, it is clear that the optimal use of technology in sports involves a balanced integration with human judgment. This hybrid approach ensures that the spirit of sportsmanship and the integrity of games are maintained.

4. Conclusion

The evolution of sports officiating, from traditional human refereeing to the integration of advanced technology, marks a significant transition in the pursuit of fairness, accuracy, and objectivity in sports. This review has explored the historical context of refereeing, the emergence of technology as a complement or substitute for human referees, and the efficacy of these technological interventions across various sports.

Refereeing, a crucial aspect of sports, has evolved dramatically. Initially relying solely on human judgment, it has now embraced technological advancements such as VAR in football, Hawk-Eye in tennis and cricket, instant replay in American football, and similar systems in other sports. These technologies have enhanced decision-making accuracy, reduced referee bias, and improved the overall quality of sports officiating. Studies have shown that technologies like VAR can increase decision accuracy (Spitz et al., 2020) and reduce home advantage bias (Kim et al., 2022), underscoring their effectiveness in creating a more level playing field. However, this technological integration is not without challenges. Concerns have been raised about the impact on the flow of the game, the potential for over-reliance on technology, and the need for consistency and clarity in the application of these systems (Nlandu, 2012; Svantesson, 2014). Furthermore, the sentiment towards technologies like VAR has been mixed among fans and players, indicating a need for better communication and implementation strategies (Kolbinger & Knopp, 2020).

The implications of this review are far-reaching. For sports governing bodies, understanding the balance between technology and human officiating is crucial for future rule amendments and implementations. For teams and players, adapting to these changes is vital for competitive success. Furthermore, recognizing the impact of technology in improving the fairness of the game could result in a more enjoyable sporting encounter for enthusiasts. Looking forward, there is significant scope for further research. Studies could focus on the long-term impacts of technology on the dynamics of different sports, the psychological effects on players and referees, and the socio-cultural implications

of technology in sports. Additionally, exploring the development of new technologies and their potential applications in sports officiating, including AI and machine learning, could provide insights into the future of sports refereeing. In conclusion, while technology has undeniably improved sports officiating, the essence of sports lies in its human elements – passion, unpredictability, and the pursuit of excellence. Maintaining a balance between technological accuracy and the human spirit of sports will be the key to preserving the integrity and enjoyment of sports in the years to come.

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