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Analysis of the Use of Video Challenge Systems in Volleyball at the 2024 Paris Olympic Games

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A B S T R A C T

Objective: The use of video-assisted officiating technologies in sports competitions has created a significant transformation in referees' decision-making processes in recent years. In particular, the Video Challenge System (VCS) in volleyball has become an important element that supports referees' decisions and may influence teams' strategic approaches in high-level events. In this context, the study aimed to provide a descriptive examination of data related to the use of the Video Challenge System in volleyball matches played at the 2024 Paris Olympic Games and to evaluate its implementation processes.

Methods and Materials: A total of 97 challenges from 25 matches were analyzed. The analysis examined the number of challenges, their approval or rejection, and their distribution by match stage, match outcome, and country, using descriptive statistics and independent t-tests conducted in an exploratory manner.

Results: The results showed that 28.87% of all challenges were upheld, while 71.13% were rejected. Winning teams submitted fewer challenges but demonstrated higher success rates in addressing them. Descriptive differences were observed across competition stages, with higher approval rates recorded in the semifinal and bronze medal matches. Variations were also observed among countries in terms of challenge frequency and outcomes. Referees rarely initiated VCS reviews, and such instances occurred infrequently across matches.

Conclusion: Overall, the findings suggest that VCS use may support referee decision-making processes and may be associated with perceived fairness, while patterns of use appear to vary according to team characteristics, competition stage, and national context. These results should be interpreted as descriptive and exploratory in nature.

Keywords: *VCS, Challenge success, Match outcomes, Olympic volleyball, Sports technology*

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1. Introduction

The integration of technology into sports competitions has undergone a significant transformation in recent years. In particular, video-assisted review systems developed in officiating have emerged as effective tools to strengthen the principles of fairness and accuracy in sporting events (1, 2). While referees' decision-making processes rely on instantaneous judgments during the fast and complex game flow, VCS helps reduce these limitations by grounding decisions on more objective foundations (3). Such technologies have become widespread across different sports branches and have significantly reduced referee errors.

Beyond improving decision accuracy, video referee systems influence referees' decision-making processes and psychological workload. For instance, the Video Assistant Referee (VAR) system in football has significantly increased the accuracy of referees' calls (2). Similarly, the application of Hawk-Eye technology in tennis has reduced officiating errors and altered referees' decision-making tendencies (4). This suggests that VCS extend beyond technical contributions to accuracy, influencing the behavior and psychology of referees (5, 6). More recently, VAR has been shown to influence not only referees' decision accuracy but also the way they exercise authority and control in decision-making (7). From the perspective of referee education, these systems also provide important opportunities, as video-based analyses have been reported to enhance referees' decision quality and consistency (7, 8). Today, video-assisted review systems are considered tools for correcting instant decisions and integral components of referee development (9).

The Video Challenge System is a prominent example of this transformation in volleyball. The fast and dynamic structure of the sport, particularly in evaluating complex situations such as line calls, block touches, and net violations, has heightened the need for video-assisted systems. Studies have shown that VCS improves referees' decision accuracy and is generally perceived positively by spectators (10, 11). Spectators report that VCS contributes to the game's fairness and enhances the reliability of the match experience (12). Alongside these positive perceptions, however, some minor drawbacks, such as interruptions in the flow of play, have also been reported (11).

The effects of video referee systems on sports ethics, cultural differences, and referee education are increasingly discussed in the literature. By reinforcing the principles of fairness and impartiality, these systems contribute to the ethical values of sport (1, 13). At the same time, it has been observed that cultural differences among countries are reflected in the adoption of such technologies, leading to variations in implementation across different regions (14). From an educational standpoint, video analysis-based learning processes have been emphasized as valuable in enhancing the quality of referees' decisions and their professional development (8, 15). These multidimensional impacts suggest that video referee technologies are both technical tools and pedagogical and cultural instruments within sport.

As one of the most competitive arenas in sport, the Olympic Games provide a unique setting where the effectiveness of technological innovations can be most clearly observed. In volleyball, the use of VCS stands out by improving referees' decision accuracy, shaping the strategic approaches of players and coaching staff, and influencing the course of matches. The analyses conducted in this study provide valuable insights into how sports technologies are applied in high-stakes contexts and contribute to the further development of these systems.

Accordingly, the aim of this study was to descriptively examine the data related to the use of the Video Challenge System in volleyball matches played at the 2024 Paris Olympic Games and to provide an evaluation of the system's implementation processes, while providing original contributions to the literature through international comparisons and insights into the patterns of system use. This study was guided by the following research questions:

- How frequently was VCS used in volleyball matches at the Paris 2024 Olympic Games, and what were the outcomes of these challenges?
- Are there descriptive differences in VCS use and challenge success between winning and losing teams?
- How does VCS use vary across competition stages, countries, and challenge reasons?

2. Methods and Materials

2.1 Research Design

This study employed a descriptive research design to document and summarize the patterns of Video Challenge System (VCS) use in volleyball matches played at the Paris

2024 Olympic Games. A descriptive approach was chosen to provide an objective overview of challenge frequency, outcomes, and distributions without manipulating variables or testing causal hypotheses (16). Additionally, the study employed a cross-sectional design, as all data were collected from matches played within a single tournament period. This design enabled the examination of VCS use at a specific point in time, reflecting the competitive context of the Olympic Games without longitudinal follow-up (17). The study was also retrospective in nature, as it relied on previously recorded match videos rather than real-time data collection. The retrospective use of archival video material allowed for systematic observation and documentation of challenge events that had already occurred (17, 18). Together, these design components were complementary and appropriate for the descriptive and exploratory objectives of the study.

2.2 Research Group

This study was conducted on a sample of volleyball teams participating in the Paris 2024 Olympic Games. The research group comprised 12 teams competing in the Olympic tournament. Each team was analyzed in terms of the average number of challenges per match, the proportion of successful and unsuccessful challenges, and data related to the use of the VCS. The participants represented teams from different countries, and data were collected regarding their strategies and decision-making processes in relation to VCS use. By employing an international sample that included teams from diverse geographical regions and cultural contexts, the study aimed to examine how different teams approached the system. This enabled the comparative assessment of variations and impacts of VCS use across countries and teams. The research group was not selected randomly; all teams participating in the tournament were included in the analysis.

2.3 Data Collection Process

The study examined the use of the Video Challenge System during volleyball competitions at the Paris 2024 Olympic Games. Data was collected through match recordings available on YouTube and official volleyball federation websites, and the impact of VCS use on decision accuracy was analyzed. All challenges made throughout the matches, along with their approval and rejection rates, were recorded and evaluated in relation to referees' decisions. The use of video recordings, obtained from high-resolution and official sources, enhanced the reliability of the data; however, it was acknowledged that certain limitations could arise due to camera angles in specific situations.

2.4 Data Collection Tools

This study utilized video recordings of volleyball matches from the Paris 2024 Olympic Games, obtained from YouTube and official volleyball federation websites, as the primary data source to examine the effectiveness of the Video Challenge System (VCS). These recordings were analyzed in detail to assess the impact of VCS on referees' decision accuracy, to observe how the challenge processes operated, and to determine the approval and rejection rates of challenges. The video materials were sourced from publicly available and officially published sources, and were used solely for academic research purposes in accordance with established ethical principles. The impartiality and uninterrupted nature of the recordings were considered essential criteria for ensuring data reliability and accuracy.

2.5 Data Analysis

In this study, the collected data were analyzed primarily using descriptive statistics. Parameters such as the total number of challenges, the proportions of successful and unsuccessful challenges, the reasons for each challenge, and the average number of challenges per match were examined. Mean values and standard deviations were calculated to summarize the data. Prior to conducting inferential analyses, the data were examined and were found to reasonably meet the assumptions of normality and variance homogeneity, and observations were treated as independent at the match level. Independent t-tests were used to explore differences between winning and losing teams in terms of challenge frequency and success rates. Given the limited sample size and the archival nature of the data, these analyses were conducted in an exploratory manner and were not intended to test causal or confirmatory hypotheses. Accordingly, statistical findings were interpreted cautiously and in conjunction with descriptive results. In addition, Cohen's d effect size was calculated to assess the practical significance of observed differences. For all analyses, a significance level of $p < .05$ was adopted.

3. Results

Table 1 presents the overall distribution of challenges recorded during the tournament. A total of 97 challenges

were observed across 25 matches, corresponding to a mean of 3.88 challenges per match. Of these, 28 challenges (28.87%) were successful, while 69 challenges (71.13%) were unsuccessful. These results summarize the frequency and outcomes of Video Challenge System (VCS) use throughout the competition. Overall, these results indicate that unsuccessful challenges were more frequent than successful challenges throughout the tournament.

Table 1. Overall Distribution of Challenges (n = 25)

Challenge Outcome	Total Count	Percentage (%)	Mean per Match	Sd
Total Challenges	97	100	3.88	1.79
Successful Challenges	28	28.87	1.12	0.97
Unsuccessful Challenges	69	71.13	2.76	1.51

Note: Mean = Average; n = Number of Matches; Sd = Standard Deviation

According to Table 2, winning teams submitted a mean of 1.80 challenges per match, whereas losing teams submitted a mean of 2.08 challenges per match. In terms of challenge outcomes, 37.8% of the challenges submitted by winning teams were successful, compared with 21.1% for losing teams. Taken together, these findings show a higher mean number of challenges among losing teams, while winning teams displayed a higher proportion of successful challenges.

Table 2. Distribution of Challenges According to Match Results

	Challenge Type	Total	Percentage (%)	Mean per Match	Sd
Winning Teams	Total Challenges	45	100	1.80	1.0
	Successful Challenges	17	37.8	0.68	0.69
	Unsuccessful Challenges	28	62.2	1.12	0.78
Losing Teams	Total Challenges	52	100	2.08	1.19
	Successful Challenges	11	21.1	0.44	0.58
	Unsuccessful Challenges	41	78.9	1.64	1.11

Note: Mean = Average; n = Number of Matches; Sd = Standard Deviation

Table 3 shows the distribution of challenges across different competition stages. The mean number of challenges per match was 3.71 during group matches, 4.00 in the quarter-finals, 5.00 in the semi-finals, and 4.00 in both the bronze medal match and the final. The proportion of successful challenges ranged from 27.0% in group matches to 40.0% in the semi-finals and 50.0% in the bronze medal match, while no successful challenges were recorded in the final. Descriptively, challenge frequency and success rates varied across competition stages, with differences observed between group matches and later elimination rounds.

Table 3. Distribution of Challenges According to Different

Competition Level	Challenge Outcome	Total	Percentage (%)	Mean per Match	Sd.
Group Matches (n=17)	Total Challenges	63	100	3.71	1.13
	Successful Challenges	17	27	1	0.66
	Unsuccessful Challenges	46	73	2.71	1.01
Quarter-finals (n=4)	Total Challenges	16	100	4	1.31
	Successful Challenges	5	31.2	1.25	0.52
	Unsuccessful Challenges	11	68.8	2.75	1.06
Semi-finals (n=2)	Total Challenges	10	100	5	-
	Successful Challenges	4	40	2	-
	Unsuccessful Challenges	6	60	3	-
Bronze Medal Match (n=1)	Total Challenges	4	100	4	-
	Successful Challenges	2	50	2	-
	Unsuccessful Challenges	2	50	2	-
Final Match (n=1)	Total Challenges	4	100	4	-
	Successful Challenges	0	0.0	0.0	-
	Unsuccessful Challenges	4	100	4	-

Note: Mean = Average; n = Number of Matches; Sd = Standard Deviation

According to Table 4, the distribution of Video Challenge System use varied across countries. Italy recorded the highest total number of challenges (n = 15), followed by Türkiye (n = 13) and China (n = 11). The Netherlands had the highest mean number of challenges per match (Mean = 4.00). Success rates varied across countries, ranging from 0.0% in the Dominican Republic and Japan to 60.0% in Poland and 45.5% in China. The United States recorded the lowest mean number of challenges per match (Mean = 1.17), with a success rate of 42.9%. Kenya recorded four challenges across three matches. When considering the three highest-ranked teams in the Olympic tournament (Italy, the United States, and Brazil), Italy recorded 15 challenges with a success rate of 40.0%, the United States recorded seven challenges with a success rate of 42.9%, and Brazil recorded 10 challenges with a success rate of 20.0%. These results demonstrate variability in both the frequency and outcomes of challenges across participating countries.

Table 4. Distribution of Challenges According to Country

Country	Challenge Outcome	Total	Percentage (%)	Mean per Match	Sd.
Türkiye (n=6)	Total Challenges	13	100	2.17	1.33
	Successful Challenges	2	15.4	0.33	0.52
	Unsuccessful Challenges	11	84.6	1.83	1.17
Netherlands (n=2)	Total Challenges	8	100	4.0	-
	Successful Challenges	2	25	1.0	-
	Unsuccessful Challenges	6	75	3.0	-
Dominican Republic (n=3)	Total Challenges	5	100	1.67	0.58
	Successful Challenges	0	0.0	0.0	0.0
	Unsuccessful Challenges	5	100	1.67	0.58
Italy (n=6)	Total Challenges	15	100	2.5	0.84
	Successful Challenges	6	40	1.0	0.89
	Unsuccessful Challenges	9	60	1.5	0.55
China (n=4)	Total Challenges	11	100	2.75	0.96
	Successful Challenges	5	45.5	1.25	0.5
	Unsuccessful Challenges	6	54.5	1.5	1.0
Brazil (n=6)	Total Challenges	10	100	1.67	0.82
	Successful Challenges	2	20	0.33	0.52
	Unsuccessful Challenges	8	80	1.33	1.03
Japan (n=3)	Total Challenges	4	100	1.33	0.58
	Successful Challenges	0	0.0	0.0	0.0
	Unsuccessful Challenges	4	100	1.33	0.58
United States (n=6)	Total Challenges	7	100	1.17	0.75
	Successful Challenges	3	42.9	0.5	0.55
	Unsuccessful Challenges	4	57.1	0.67	0.82
Poland (n=4)	Total Challenges	5	100	1.25	0.5
	Successful Challenges	3	60	0.75	0.5
	Unsuccessful Challenges	2	40	0.5	0.58
Serbia (n=4)	Total Challenges	10	100	2.50	1.29
	Successful Challenges	2	20	0.50	0.58
	Unsuccessful Challenges	8	80	2.00	1.41
France (n=3)	Total Challenges	5	100	1.67	0.58
	Successful Challenges	2	40	0.67	0.58
	Unsuccessful Challenges	3	60	1.0	1.0
Kenya (n=3)	Total Challenges	4	100	1.33	1.53
	Successful Challenges	1	25	0.33	0.58
	Unsuccessful Challenges	3	75	1.0	1.0

Note: Mean = Average; n = Number of Matches; Sd = Standard Deviation

According to Table 5, block touch was the most frequent reason for challenges (Total = 66; Mean = 2.64 per match), followed by net touch (Total = 20). Other challenge reasons, including ball contact with the court, center line violation, and in/out errors, occurred infrequently. Successful challenges were recorded for block touch (n = 21) and ball contact with the court (n = 2), whereas no successful challenges were observed for center line violations or in/out errors. Block touch challenges accounted for the majority of VCS use, whereas other challenge reasons occurred relatively infrequently.

Table 5. Distribution According to Reasons for Challenge

Challenge Reason (n=25)	Outcome of Challenges	Total	Percentage (%)	Mean per Match	Sd.
In/Out Errors	Total Challenges	1	100	0.04	0.20
	Successful Challenges	0	0.0	0.0	0.0
	Unsuccessful Challenges	1	100	0.04	0.20
Ball Contact with Antenna	Total Challenges	2	100	0.08	0.28
	Successful Challenges	1	50	0.04	0.20
	Unsuccessful Challenges	1	50	0.04	0.20
Block Touch	Total Challenges	66	100	2.64	1.80
	Successful Challenges	21	31.8	0.84	0.94
	Unsuccessful Challenges	45	68.2	1.80	1.44
Net Touch	Total Challenges	20	100	0.80	0.72
	Successful Challenges	4	20	0.16	0.47
	Unsuccessful Challenges	16	80	0.64	0.57
Center Line Violation	Total Challenges	4	100	0.16	0.37
	Successful Challenges	0	0.0	0.0	0.0
	Unsuccessful Challenges	4	100	0.16	0.37
Ball Contact with Court	Total Challenges	4	100	0.16	0.37
	Successful Challenges	2	50	0.08	0.28
	Unsuccessful Challenges	2	50	0.08	0.28
Total	Total Challenges	97	100	3.88	1.79
	Successful Challenges	28	28.87	1.12	0.97
	Unsuccessful Challenges	69	71.13	2.76	1.51

Note: Mean = Average; n = Number of Matches; Sd = Standard Deviation

Table 6 presents the distribution of VCS requests initiated by referees. Across the 25 matches analyzed, referees initiated a total of eight challenges, corresponding to a mean of 0.32 per match. These referee-initiated challenges were distributed across different types of decisions, including ball contact with the antenna, block touch, net touch, center line violation, and ball contact with the court. Referee-initiated challenges constituted a small proportion of total VCS use across the analyzed matches.

Table 6. Distribution of Video Challenge System Requests Initiated by Referees (n = 25)

Reason for Challenge	Total	Percentage (%)	Mean per Match	Sd.
Ball Contact with Antenna	2	25	0.08	
Block Touch	1	12,5	0.04	
Net Touch	2	25	0.08	
Center Line Violation	1	12,5	0.04	
Ball Contact with Court	2	25	0.08	
Total	8	100	0.32	0.02

Note: Mean = Average; n = Number of Matches; Sd = Standard Deviation

Table 7 compares winning and losing teams with respect to total, successful, and unsuccessful challenges. Losing teams recorded a higher mean number of total challenges per match ($\bar{X}$ = 2.08) than winning teams ($\bar{X}$ = 1.80); however, this difference was not statistically significant (t = −0.902, p = 0.37). Similarly, the mean number of unsuccessful challenges was higher for losing teams ($\bar{X}$ = 1.64) compared with winning teams ($\bar{X}$ = 1.12), with the difference approaching but not reaching statistical significance (t = −1.912, p = 0.06). The mean number of successful challenges was higher for winning teams ($\bar{X}$ = 0.68) than for losing teams ($\bar{X}$ = 0.44), although this difference was also not statistically significant (t = 1.328, p = 0.19).

Table 7. Comparative Statistics of Challenges According to Winning and Losing Teams

Outcome of Challenges	Winners ($\bar{X}$) (n=25)	Losers ($\bar{X}$) (n=25)	t	p	Cohen's d
Total Challenges	1.8	2.08	-0.902	0.37	0.255_{SES}
Successful Challenges	0.68	0.44	1.328	0.19	0.376_{SES}
Unsuccessful Challenges	1.12	1.64	-1.912	0.06	0.541_{SES}

Note: $\bar{X}$ = Mean; n = Number of Matches; SES = Small effect size (according to Hopkins' classification).

4. Discussion

Video Challenge Systems and similar referee-assisting technologies have become important tools in recent years for ensuring fair officiating and improving the accuracy of referees' decisions. These technologies allow referees to examine situations that are difficult to perceive with the naked eye, particularly in critical moments, in a more objective manner (2). Research on football, tennis, and basketball has shown that video-assisted systems significantly enhance referee accuracy (4, 6). In volleyball, the VCS has also been reported to improve decision quality and contribute to the reliability of matches for both players and spectators (11, 12). Consistent with previous studies, the findings of this research may suggest that the VCS can support referee decision-making and match management, rather than demonstrating definitive improvements in decision accuracy (11, 15).

Accuracy in refereeing decisions is a fundamental element for maintaining fair competition in sports. However, errors are inevitable since decisions are often based on limited perspectives and rapid judgments (2, 5). In this study, 71.13% of challenges were unsuccessful, which may indicate that referees' initial decisions were generally accurate within the observed matches. In comparison, the 28.87% of successful challenges could reflect the corrective function of the VCS in situations that may not be easily detected in real time. Similarly, research has shown that the use of VAR in football increased decision accuracy from 92.1% to 98.3%, and the use of Hawk-Eye in tennis reduced error rates by 8% (2, 4). In volleyball, most referees have emphasized that the VCS significantly contributes to the quality and reliability of decisions (3, 10, 12). Together, these findings align with previous literature suggesting a supportive role of VCS in refereeing.

One of the findings of this study concerns the differentiation in VCS usage strategies between winning and losing teams. Winning teams submitted fewer challenges but achieved higher success rates, which may suggest differences in how teams approach the use of the VCS. In contrast, losing teams faced more challenges, but most were unsuccessful. These patterns should be interpreted as exploratory and do not imply causal relationships between VCS use and match outcomes. Similarly, studies have reported that VAR altered the behaviors of players and teams in the Turkish Super League (19) and that Hawk-Eye influenced referees' decision-making tendencies in tennis (4). In volleyball, referees were found to use the VCS more cautiously during critical matches (10). From an exploratory perspective, the more selective use of challenges by winning teams may be associated with situational awareness and match context rather than performance outcomes alone.

As competition levels intensify, competitive pressure and psychological stress increase, which may be reflected in the observed distribution and outcomes of VCS use across different competition stages. This is consistent with descriptively higher challenge frequencies and approval rates observed in the semi-final and bronze medal matches. The rejection of all challenges in the final may reflect increased caution in officiating or limitations related to the small sample size at this stage. Comparable trends have been observed in football, where the frequency of VAR usage increases with the importance of the tournament stage (2), and in volleyball, where referees and teams adjust their VCS strategies based on match importance (10). Thus, the VCS can be viewed not only as a technical tool but also as a contextual element shaped by competitive dynamics.

This study also revealed noticeable differences in VCS usage among countries. The Netherlands, China, and Italy recorded higher challenge rates, whereas Japan, the United States, and Kenya had lower ones. Among the top three teams in the Olympic rankings, Italy submitted the highest number of challenges (15) with an approval rate of 40.0%; the United States adopted a more cautious approach with seven challenges but achieved a relatively high approval rate of 42.9%; Brazil filed 10 challenges with only 20% approved. These country-based differences should be interpreted descriptively, as they may stem from technical preferences, strategic decisions, or cultural approaches. The literature also highlights that cultural norms can influence the adoption of sports technologies (4, 14). Therefore, the findings suggest that variability in VCS usage may extend beyond quantitative differences, encompassing broader contextual factors.

The limited number of referee-initiated VCS requests indicates that this technology is perceived not as a constant intervention tool but as a supportive mechanism in critical decision-making moments. Such selective use may help referees manage complex situations without over-reliance on technology, as also reported in previous studies (4, 6, 8, 10). Similarly, in the context of VAR, referees have been shown to use technology strategically while retaining ultimate authority in decision-making. This finding is consistent with the selective use of VCS in this study (7). These findings support the interpretation of VCS as an

auxiliary tool that complements, rather than replaces, referee judgment.

The findings suggest that the VCS may contribute to perceived fairness, decision accuracy, and match management quality in volleyball competitions. However, the strategies that teams and referees adopt appear to vary depending on the match's importance, level of competition, and cultural factors. Previous research has also emphasized that video-assisted referee technologies enhance perceptions of fairness and spectator confidence, while also highlighting areas requiring further development (1, 2, 6, 13, 14). Therefore, it is essential that the VCS be continuously improved in terms of transparency, speed, and standardization, and that referees be supported in applying it in a balanced manner. In conclusion, technologies such as the VCS can be considered important supportive mechanisms in the fair management of sports competitions. A holistic approach that considers not only the technical capacity of these systems but also the human factor is crucial for their sustainable implementation.

4.1 Limitations

This study was conducted with a retrospective and descriptive design and has several limitations. The findings are based solely on volleyball matches from the 2024 Paris Olympic Games and should therefore be interpreted within the context of elite, short-term international competition, which limits their direct generalizability to other tournaments, leagues, age groups, or competitive levels. Since the data were obtained exclusively from video recordings, uncontrollable psychological factors such as referee stress, cognitive load, pressure related to match importance, and situational decision-making processes could not be directly observed or measured.

Furthermore, individual referee characteristics, including experience level, prior exposure to the Video Challenge System, and officiating style, were not included as analytical variables and may have influenced decision-making patterns. Similarly, coaching tactics and strategic preferences related to challenge usage, such as risk tolerance or match-specific decision strategies, were not controlled for. Cultural differences were considered descriptively but not examined as independent explanatory variables.

Additionally, findings related to certain competition stages and teams should be interpreted with caution due to the limited and unequal number of matches within these categories. Future research should examine competitions at various performance levels, incorporate qualitative data from referees, coaches, and players, and assess the long-term and cross-contextual effects of the VCS to provide a more comprehensive understanding of its role in officiating processes.

Authors' Contributions

SO and SA contributed significantly to the conception and design of the manuscript. SO was responsible for data collection, while SA, CG, and SU were responsible for data analysis and interpretation. All authors contributed to drafting the manuscript and critically revised its content. All authors read and approved the final version of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

The study was conducted after receiving ethical approval from the Erzurum Teknik Üniversitesi Scientific Research and Publication Ethics Committee (Decision No. 5, Meeting No. 15, dated December 5, 2024).

References

1. Dyer B. The controversy of sports technology: a systematic review. Springerplus. 2015;4:524. [PMID: 26405644] [PMCID: PMC4575312] [DOI]
2. Spitz J, Wagemans J, Memmert D, Williams AM, Helsen WF. Video assistant referees (VAR): The impact of technology on decision making in association football referees. Journal of Sports Sciences. 2021;39(2):147-53. [PMID: 32794432] [DOI]
3. Haake SJ. The impact of technology on sporting performance in Olympic sports. J Sports Sci. 2009;27(13):1421-31. [PMID: 19764001] [DOI]
4. Almog D, Gauriot R, Page L, Martin D, editors. AI oversight and human mistakes: evidence from centre court. Proceedings of the 25th ACM Conference on Economics and Computation; 2024. [DOI]
5. Bacigalupe C. The video assistant referee (VAR) protocol. The use of video technologies in refereeing football and other sports: Routledge; 2019. p. 183-207. [DOI]
6. Pizzera A, Marrable J, Raab M. The video review system in association football: implementation and effectiveness for match officials and referee education. Managing Sport and Leisure. 2022. [DOI]
7. Garretsen H, Stoker JI, Alessie R. Who rules in times of the Video Assistant Referee? On referees' decision making in football. Psychology of Sport and Exercise. 2025;81. [PMID: 40669801] [DOI]
8. Frevel N, Beiderbeck D, Schmidt SL. The impact of technology on sports - A prospective study. Technological Forecasting and Social Change. 2022;182. [DOI]
9. Altintas N, Duman S. The effect of the video evaluation system used by the top leagues of the Turkish Volleyball Federation on the decision-making of referees. Journal of ROL Sport Sciences. 2024;5(3):424-45. [DOI]
10. Çevik R, Bilgin M, Şahin M. Evaluation of Video Challenge System in Volleyball from the Points of Classification Referees. European Journal of Education Studies. 2023;10(12). [DOI]
11. Çevik R, Şahin M. Examination of the video evaluation system in indoor volleyball according to the perspective of the spectator. Eurasian Journal of Researches in Social and Economics. 2023;10(2):161-76.
12. Akarçeşme C, Aka H, Aktuğ ZB, İbiş S, Altundağ E. An Analysis on the Video Evaluation System in Volleyball. Gazi Journal of Physical Education and Sport Sciences. 2023;28(1):73-7. [DOI]
13. Şahin M. Sports Ethics and Issues: Evrensel Publishing; 2014.
14. Teixeira da Silva JA, Nazarovets S, Carboch J, Deutscher C, Almeida CH, Webb T, et al. The video assistant referee in football. Sports Eng. 2024;27(1). [DOI]
15. Ghezelsefloo H, Alavi S. The Impact of event-based sports technologies on the training and career development of referees in Iran volleyball super league. Technology of Education Journal (TEJ). 2022;16(2):351-62. [DOI]
16. Karasar N. Scientific research methods: Concepts, principles, techniques (26th ed.). Nobel Academic Publishing. 2014.
17. Creswell JW, Creswell JD. Research design: Qualitative, quantitative, and mixed methods approaches: Sage publications; 2017.
18. Hess DR. Retrospective studies and chart reviews. Respir Care. 2004;49(10):1171-4. [PMID: 15447798]
19. Isin A, Yi Q. Does video assistant referee technology change the magnitude and direction of home advantages and referee bias? A proof-of-concept study. Bmc Sports Sci Med R. 2024;16(1). [PMID: 38238850] [PMCID: PMC10797986] [DOI]