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The Communicative Potential of Virtual Reality in Sports Journalism: Insights from Meta-Analytical Studies

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ABSTRACT

Virtual Reality (VR) has increasingly been integrated into sports journalism to facilitate immersive storytelling and enhance audience engagement. Despite its growing adoption, a systematic synthesis of its communicative effectiveness remains scarce within communication research. This study addresses this gap through a meta-analysis of 22 peer-reviewed studies published from 2016 to 2024, following PRISMA guidelines. Effect sizes were extracted and analyzed using fixed-effects and random-effects models. The findings indicate a significant positive overall effect of VR on audience engagement and content-related outcomes in sports journalism. Nevertheless, substantial heterogeneity was observed across the included studies, indicating that the communicative impact of VR is contingent upon specific research contexts and implementation conditions. This research provides empirical support for VR's potential to enhance digital sports news experiences, while also highlighting the importance of accessibility, ethical considerations, and sustained audience engagement. The findings establish a foundation for advancing VR journalism practices and suggest that future research should prioritize long-term evaluations and the standardization of reporting metrics.

Keywords: Virtual Reality (VR), Sports Journalism, Immersive Journalism, Audience Interaction, Meta-Analysis.

INTRODUCTION

VR news proves superior in terms of immersion, interest, accuracy, and credibility (Eskiadi & Panagiotou, 2025), while offering audiences a more interactive and engaging virtual experience in the consumption and interpretation of news content (Herrera Damas & Benítez de Gracia, 2022; Greber, Aaldering, & Lecheler, 2024). Sports journalism, in particular, benefits greatly from VR's communication capabilities, as immersive technologies allow viewers to experience sporting events as if they were physically present (Neumann et al., 2018; Javani, Ansari, & Abdavi, 2024), and provide arena-like, at-home viewing experiences for sports spectators (Regret, Pavlik & Jin, 2022). Collectively, these developments are reshaping how audiences access, experience, and engage with sports news content (Choudhary & Sahu, 2023; Sarkar & Ghosh, 2023).

The application of VR in journalism began gaining traction around 2010 (Uskali, Gynnild, Jones & Sirkkunen, 2021), but it was not until 2016 that it became more widely adopted (Aitamurto, Aymerich-Franch, Saldivar, Kircos, Sadeghi, & Sakshuwong, 2022). Since then, VR technology has been increasingly applied across different areas of journalism, with sports journalism emerging as one of the most prominent fields of adoption. This prominence is closely related to the distinctive characteristics of sports news, including its emphasis on immediacy, visual intensity, and emotional engagement, which align particularly well with the immersive and interactive features of VR technology(Kim & Ko, 2019; Goebert, Greenhalgh, & Dwyer, 2022). As a result, sports journalism provides a critical and representative context for examining how VR technology reshapes news

storytelling, audience experience, and journalistic practices(Sarkar & Ghosh, 2023；Zhou & Zhang, 2025).

Against this backdrop, the growing adoption of VR in sports journalism points to the need for a systematic examination of its communicative potential. In light of this evolving technological landscape, this research analyzes the impact of VR on sports news delivery by synthesizing research findings on the technology's progression in news communication. Specifically, it reviews key developments in immersive reporting, with a focus on narrative techniques, audience engagement, and news distribution methods.

Problem Statement

The rapid adoption of Virtual Reality (VR) technology in sports journalism has transformed how audiences consume and engage with news, highlighting the need for further scholarly examination of its communicative potential. Despite its growing application, VR-driven storytelling is still evolving, as practical implications and the lack of robust audience measurement systems continue to call for further research. Although 2016 was hailed as the "Year of VR Journalism" and the 2024 Paris Olympics saw its widespread implementation, empirical evidence remains insufficient to substantiate its long-term impact on sports news coverage.

Moreover, the use of VR in journalism is accompanied by two major challenges: technological constraints and ethical considerations, both of which affect journalistic trustworthiness and the quality of audience interaction. Given VR's relatively recent emergence as a media innovation, research has yet to determine the extent to which it sustains audience engagement once the initial "novelty effect" wears off.

Despite the growing interest in virtual reality (VR) as a tool for immersive storytelling, there remains a significant research gap concerning its long-term communicative impact within sports journalism (Kukkakorpi & Pantti, 2021; Greber et al., 2023). While recent studies highlight VR's capacity to enhance engagement, emotional resonance, and realism in news reporting, limited empirical evidence exists regarding how VR influences audience behavior, news credibility, and journalistic practices over time (Herrera Damas & Benítez de Gracia, 2022; Wang et al., 2024). Furthermore, most existing research focuses on short-term user experiences or experimental settings (Meijer, 2022; Park, Koo, Kim, & Kim, 2025), underscoring the need for a meta-analytical synthesis to evaluate VR's broader communicative role within the evolving sports media landscape.

Research Questions

How does VR technology enhance immersion, interactivity, and audience engagement in sports journalism?

What is the communicative potential of VR in the context of sports journalism?

The Research Purpose and Significance

A primary objective of this investigation is to conduct a meta-analysis of existing research on Virtual Reality (VR) applications in sports journalism. By synthesizing prior studies, this research traces the adoption and development of VR technology in sports journalism, from its recognition in 2016 as the "Year of VR Journalism" to its expanded use in the coverage of the Paris 2024 Olympic Games. Furthermore, it examines how VR enhances audience engagement and fosters innovative storytelling practices in sports news dissemination.

Moreover, this research evaluates VR applications in sports journalism by examining their communicative potential and future development directions. Through a meta-analytical approach, evidence from diverse sources is integrated to enhance understanding of how VR technology influences sports journalism reporting, particularly through immersive storytelling that enables higher levels of audience participation. These insights are essential for media organizations, journalists, and technology developers seeking to optimize VR-driven sports coverage.

Additionally, this research investigates the core challenges associated with VR implementation, such as accessibility barriers and concerns regarding ethical and professional integrity. Extensive research on VR in sports journalism provides an robust and important foundation for theoretical inquiry and further innovation in sports journalism studies. The findings are expected to enrich the ongoing scholarly discourse on immersive technologies and offer practical guidance for media practitioners and researchers on optimizing VR applications for news reporting.

Overall, by systematically assessing the affordances and constraints of VR-based sports journalism, this study seeks to elucidate how professional standards and journalistic practices can be upheld within immersive environments. The theoretical framework developed herein aims to support media professionals in refining VR practices, ultimately contributing to the ongoing evolution of sports news production and distribution.

LITERATURE REVIEW

Application of VR Technology in Journalism

Virtual Reality (VR) news, also referred to as immersive journalism, 360-degree journalism, or 360-degree video news, is discussed in the literature under several related terms(Vettehen, Wiltink, Huiskamp, Schaap, & Ketelaar, 2019; Kim & Lee, 2022; Jackson & Stubbs, 2025). While these terms are often used to describe similar journalistic practices, they are not always interchangeable, reflecting ongoing conceptual debates concerning the scope, boundaries, and technological configurations of immersive news formats (Zhou, 2022;Lopezosa, Codina, Fernández-Planells, & Freixa, 2023).

Despite these terminological differences, existing studies generally converge at a functional level on the view that VR-related news practices employ immersive technologies to provide audiences with experiential access to news events. Such practices typically emphasize spatial presence, first-person perspectives, and an enhanced sense of immersive engagement (Sirkkunen, 2022; Pérez-Seijo,Vicente, & López-García,2022; González & Serra, 2024). From this perspective, VR news can be understood as a form of immersive journalism that extends traditional news storytelling through immersive and interactive technologies. These technologies most commonly include VR and 360-degree video formats and share broader experiential goals with other immersive media applications (Greber et al., 2023; Wu, 2024).

Scholarly attention to immersive and VR-based journalism can be traced back to the early 2010s, when experimental projects and conceptual discussions began to explore the potential of immersive media for news storytelling (De la Peña et al., 2010; Uskali et al., 2021). Between 2015 and 2017, the integration of VR technologies by major news organizations marked a turning point in the development of VR journalism(Wu, 2024; González & Serra,2024). During this period, immersive news formats gained increased visibility in professional practice, which in turn stimulated a growing body of academic research on VR-based news production and consumption (Sirkkunen, 2022; Sanchez-Acedo et al., 2023).

Since then, research on VR news has expanded considerably. A number of studies have approached the topic from the perspective of news production, examining how VR technologies influence journalistic practices, storytelling approaches, and professional norms (Pavlik, 2020; Uskali et al., 2021; Wu, 2024; Jackson & Stubbs, 2025). Other research has focused on the role of media platforms and technological implementation, exploring how VR is applied across different news genres and formats, as well as the communicative possibilities enabled by immersive technologies (Rodriguez-Fidalgo & Paíno-Ambrosio, 2022; Lopezosa et al., 2023; González & Serra, 2024). Alongside these strands, an increasing body of work has turned to the audience, investigating user experience, levels of engagement, and technology acceptance in the context of VR-based news consumption (Vettehen et al., 2019; Kim & Lee, 2022; Greber et al., 2024; Eskiadi & Panagiotou, 2025).

While prior research has demonstrated the potential of VR to enhance emotional engagement and experiential understanding, scholars have also highlighted persistent barriers related to technological accessibility, production costs, and ethical concerns surrounding visual manipulation and journalistic credibility (Kukkakorpi & Pantti, 2021; Herrera Damas & Benítez de Gracia, 2022; Schrottenbacher et al., 2025). Empirical and review-based studies further indicate that immersive and VR-based journalistic practices can be effective in enhancing audience experience and engagement under certain conditions, although their long-term communicative impact and sustainability beyond novelty effects remain open to scholarly discussion (Aitamurto et al., 2022; Greber et al., 2024; Feng & Murakami,2025).

Application Characteristics of VR Technology in Sports Journalism

With the wider adoption of immersive technologies in journalism, sports journalism has emerged as one of the most prominent domains for the application of Virtual Reality (VR). Owing to its emphasis on live action, spatial dynamics, and audience engagement, sports reporting provides particularly favorable conditions for immersive storytelling (Regret et al., 2022; Vincent & Frewen,2023; Greber et al., 2024). In professional practice, VR technologies have been increasingly applied to the coverage of major international sporting events, such as the 2018 Russia FIFA World Cup and the 2022 Qatar FIFA World Cup (Regret et al., 2022), the Beijing Winter Olympics (Şimşek, 2025), and the Tokyo Summer Olympics (Dubinsky, 2025). Recent studies further note that the 2024 Paris Olympics, which has been described in the literature as the first "AI Olympics", represented a notable development in VR sports journalism by integrating VR with AI-driven technologies to expand immersive sports viewing experiences (Şimşek& Devecioğlu, 2025).

Building on these professional practices, scholarly research has examined how VR technologies reshape sports journalism at both the production and consumption levels. A central research focus concerns the use of

360-degree video and VR head-mounted displays to enhance spatial presence and co-location, enabling audiences to experience sporting events from perspectives that are not accessible through conventional news formats (Neumann et al., 2018; Kunz& Santomier, 2020; Vincent & Frewen,2023). Studies on immersive and 360-degree journalism further indicate that such formats encourage a shift from fixed-camera viewing toward more exploratory forms of engagement, allowing users to navigate virtual environments and experience events from multiple viewpoints (Vettehen et al., 2019; González & Serra, 2024; Javani et al., 2024).

The suitability of VR for sports journalism can be further explained through the distinctive characteristics of sports news production and consumption. Immediacy is a defining feature of sports journalism, as audiences expect real-time updates, live broadcasts, and instant analysis. VR technologies extend this immediacy by enabling immersive live or near-live experiences that increase audience involvement with unfolding sports narratives (Kim & Ko, 2019; Nikolaou, Schwabe, & Boomgaarden, 2022). Interactivity represents another core characteristic, given that sports audiences actively participate in content consumption through multiple platforms and social interactions. VR enhances this interactive dimension by allowing users to explore 360-degree environments, switch viewing angles, and engage with virtual spaces surrounding sporting events (Goebert et al., 2022). Moreover, the profound emotional resonance of sports storytelling, which is often predicated on identification with athletes and teams, is amplified through immersive visuals that elicit stronger affective responses and fan attachment (Regret et al., 2022; Greber et al., 2024).

Despite these advantages, existing research consistently identifies several challenges that constrain the broader adoption of VR in sports journalism. High production costs, limited accessibility of VR hardware, and substantial technical requirements remain significant barriers to large-scale implementation (Kukkakorpi & Pantti, 2021; Matsiola et al., 2022). Scholars have also raised ethical concerns regarding visual manipulation, perceived authenticity, and the preservation of journalistic credibility in immersive news environments (Aitamurto et al., 2022; Herrera Damas & Benítez de Gracia, 2022; Schrottenbacher et al., 2025). Consequently, while VR holds considerable potential to transform sports journalism, its long-term integration into sports media ecosystems depends on addressing technological, ethical, and professional constraints through sustained empirical research and industry practice (Hopkins, 2017; Antoine et al., 2022; Meijer, 2022)

The Relationship Between VR and Communication Effectiveness

Sports journalism has been widely discussed as a news genre in which Virtual Reality (VR) can enhance communication effectiveness, largely due to its capacity to deliver high levels of immersion and user participation. Compared with conventional news delivery that relies primarily on passive consumption, VR provides an interactive and multi-sensory experience that allows audiences to engage more actively with mediated content (Vettehen et al., 2019; Chen, 2024). Research suggests that the introduction of VR technologies can transform traditional news consumption into sensory-based and experience-oriented interactions, a shift that appears particularly compatible with sports journalism (Kim & Lee, 2022； Sun & Zhang, 2024).

The immersive storytelling affordances of VR enable audiences to feel more directly involved in sports events, thereby supporting deeper emotional understanding of competitive action (Rodríguez & Paíno, 2022; Park et al., 2025). This effect is closely related to the heightened sense of presence enabled by VR, as users are able to participate more actively rather than remaining passive spectators (Kukkakorpi & Pantti, 2021;Jia et al., 2024; Dubinsky, 2025). One of the central communicative advantages of VR therefore lies in its ability to strengthen emotional connections between audiences and news content. Existing studies indicate that VR-based sports journalism is associated with stronger emotional engagement and closer affective ties between viewers and the events being reported (Kunz& Santomier, 2020; Capasa, Zulauf, & Wagner, 2022; Greber et al., 2023).

Beyond emotional involvement, VR journalism fosters enhanced user interaction through its unique technological affordances. By enabling audiences to navigate diverse viewing perspectives and explore virtual environments proximal to sporting events, VR encourages more active participation in news narratives, which may deepen users' perceived involvement in stories (Brambilla et al., 2024; Greber et al., 2024). In contrast to conventional sports media formats, immersive presentations that facilitate interactive engagement frequently yield higher levels of user satisfaction and perceived value. Nonetheless, their influence on information retention appears to vary across users and contexts rather than yielding uniform effects (Meijer, 2022; Feng & Murakami, 2025).

Despite these potential benefits, the communication effectiveness of VR in journalism is tempered by several operational and normative challenges. High production costs and dependency on specialized hardware, such as head-mounted displays and motion-tracking systems, continue to limit the accessibility of VR-based news experiences for wider audiences (Kang et al., 2019; Jia et al., 2024). In addition, prolonged immersion in virtual environments may result in cognitive strain and physical discomfort, which can negatively affect user experience

and reduce overall communicative effectiveness (Barnidge et al., 2022； Rosendahl et al., 2022; Javani et al., 2024). Scholars have further raised ethical concerns regarding visual manipulation, perceived authenticity, and the maintenance of journalistic credibility in immersive news formats (Uskali et al., 2021; Herrera Damas & Benítez de Gracia, 2022; Aitamurto et al., 2022; Greber et al., 2024). Accordingly, while VR exhibits considerable potential to improve communication effects in sports journalism, its widespread adoption remains contingent upon overcoming these financial, technological, and ethical constraints.

Literature Gap

While virtual reality (VR) is increasingly recognized as a transformative communication tool in sports journalism, several critical gaps persist in current scholarship. Previous studies have highlighted VR's immersive and persuasive capacities; however, they frequently examine immersion and interactivity in isolation, offering limited insight into how these dimensions collectively enhance audience engagement. Additionally, existing research primarily centers on short-term exposure, leaving the long-term cognitive outcomes of VR-based sports news, such as attention and knowledge retention, underexplored. Moreover, although accessibility barriers including high implementation costs and limited digital literacy have been acknowledged, standardized frameworks for evaluating their influence on the communicative potential of VR remain absent. To address these gaps, this study adopts a meta-analytic approach to synthesize empirical evidence and evaluate the extent to which VR technologies bolster immersion and interactivity, thereby assessing their broader communicative potential in sports journalism.

RESEARCH METHODOLOGY

Research Design

The meta-analytic process enables researchers to evaluate quantitative research about Virtual Reality (VR) communication in sports journalism thus obtaining information about audience impact and storytelling methods alongside participation effectiveness. The research analyzes empirical peer-reviewed studies which study VR technology implementations in sports media by examining both 360-degree streaming technology together with AI-enhanced VR interaction development. The research follows PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards for maintaining specific entry procedures across study stages including selection and evaluation and inclusion.

A comprehensive search for relevant literature was conducted in Scopus, Web of Science, PsycINFO, and Google Scholar using joint keyword research about virtual reality, sports journalism, immersive journalism, technological advancements, audience interaction and media engagement strategies to obtain research papers. The literature search was limited to studies published between 2016 and 2024. This period was selected because 2016 is widely recognized as the"Year of VR Journalism," marking the transition from experimental exploration to broader institutional adoption of VR technologies in professional journalism, particularly in sports media. The end of 2024 was chosen as it represents the most recent complete year of peer-reviewed publications available at the time of data collection and reflects a relatively mature stage of VR journalism development. Restricting the sample to this period allows the analysis to focus on empirical studies produced during the most active phase of VR journalism development.

Researchers used the Comprehensive Meta-Analysis (CMA) software to conduct an assessment of how Virtual Reality affects the effectiveness of sports journalism in their collected papers. Researchers used previous study effect size figures to analyze the success of Virtual Reality tactics to maintain audience focus and understanding retention. Heterogeneity analyses in combination with publication bias tests enhance the research reliability and validity so developers can use them as a basis for sports media technological growth."

Inclusion and Exclusion Criteria

To ensure the selection of high-quality and relevant studies, this research applies a rigorous set of inclusion and exclusion criteria. The criteria are designed to focus on empirical studies that specifically examine the communicative potential of Virtual Reality (VR) in sports journalism. Studies are selected based on their methodological rigor, relevance to the research topic, and availability of quantitative data. The **Table 1** below outlines the specific criteria used to determine the eligibility of studies for inclusion in this meta-analysis.

Table 1. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Type of Study	Empirical, peer-reviewed research with quantitative data	Theoretical papers, opinion pieces, literature reviews
Research Focus	VR applications related to sports journalism, including audience engagement, interactivity, and immersion	VR studies unrelated to sports journalism (e.g., educational or business reporting)
Publication Source	Academic journals, conference proceedings, and reputable databases (Scopus, Web of Science, PsycINFO, Google Scholar)	Non-peer-reviewed sources, preprints without formal review
Methodology	Experimental, quasi-experimental, or survey-based research	Studies lacking quantitative data or effect size measurements
Publication Date	January 2016–December 2024	Studies published outside the period 2016-2024
Data Uniqueness	Original research with unique datasets	Duplicate studies or multiple publications using the same dataset

Data Extraction

This study follows a structured data extraction process to systematically collect and analyze relevant information from selected empirical studies on the communicative potential of Virtual Reality (VR) in sports journalism. After applying the inclusion and exclusion criteria, eligible studies are carefully reviewed to extract key data points essential for the meta-analysis. The extraction process begins with the identification and documentation of study metadata, including author names, publication year, journal source, and geographical focus. Next, data related to research methodology is gathered, including study design, sample size, and statistical techniques employed. A crucial aspect of data extraction involves categorizing the VR applications examined in each study, such as 360-degree video, immersive live streaming, and AI-enhanced VR experiences. Additionally, this study records outcome measures relevant to audience engagement, interactivity, immersion, and the effectiveness of VR-based news dissemination.

When a study reported multiple relevant outcomes, only one effect size was selected per independent sample to prevent unit-of-analysis errors and over-weighting. A pre-specified hierarchical order was followed. First, priority was given to the outcome that best captured the core aspects of VR's communicative potential, such as immersion, vividness, or presence. Second, the primary outcome explicitly identified by the authors was selected. Third, preference was given to the outcome with the most complete data or the largest sample size. Finally, the outcome showing the strongest effect was chosen to provide a comprehensive assessment of the findings. To ensure accuracy and reliability, the extracted data undergoes a rigorous verification process, where findings are independently reviewed and cross-checked against the original studies. Any discrepancies are resolved through systematic validation. Finally, the data was structured for quantitative analysis using Comprehensive Meta-Analysis (CMA) software (Version 4), which allowed for a robust evaluation of VR's impact on sports journalism.

PRISMA Framework

Figure 1 illustrates the study selection process following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 guidelines. Initially, 487 records were identified through systematic database searches in PubMed, PsycINFO, Web of Science, and Scopus. After the removal of 65 duplicate records, 422 records remained for screening. During this phase, 245 records were excluded, including grey literature (n=227) and publications in non-English languages (n=18). Subsequently, 177 full-text reports were assessed for eligibility. Of these, 155 reports were excluded at the eligibility stage because they were not related to Virtual Reality in sports journalism (n=98) or did not provide sufficient quantitative data for synthesis (n=57). Ultimately, 22 studies met the inclusion criteria and were incorporated into the systematic review and meta-analysis. This selection process resulted in a final sample of studies aligned with the objective of evaluating the communicative potential of Virtual Reality in sports journalism.

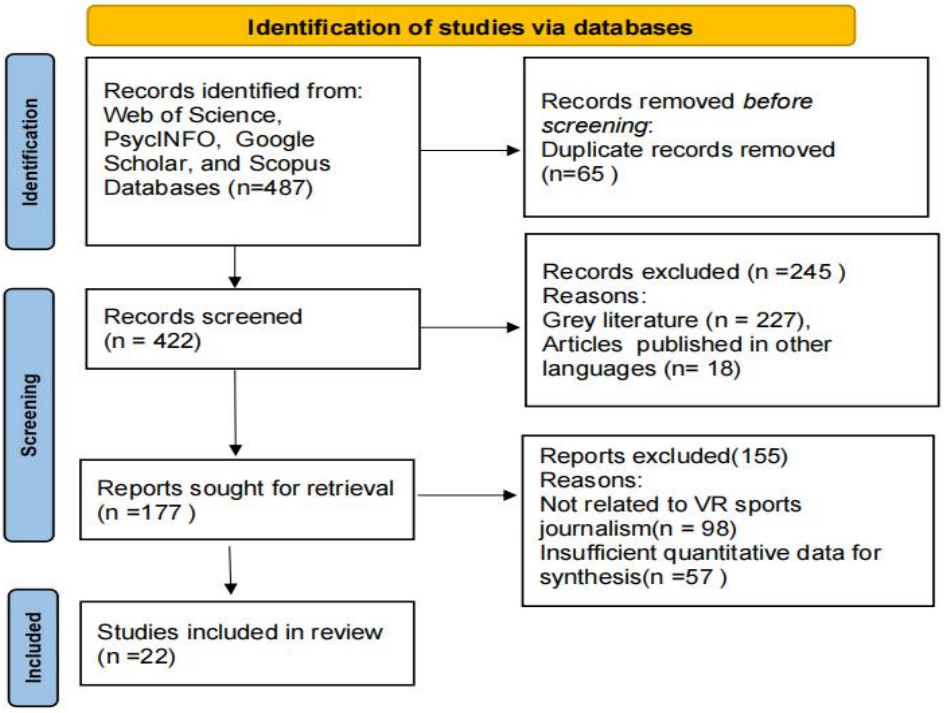

Figure 1. PRISMA Flow Diagram for Study Selection

Data Analysis

This meta-analysis employed a data analysis framework to synthesize quantitative statistics from various sports journalism studies regarding Virtual Reality (VR) communicative potential. Statistical results obtained from past academic research were compiled and utilized to examine VR effects on sports reporting through enhanced immersion, improved interactivity, and audience involvement. Effect size data were extracted directly from the included studies when available, or calculated based on reported statistical information to ensure comparability across studies. Furthermore, all reported outcomes were converted into standardized effect sizes prior to aggregation to facilitate meaningful comparisons across studies.

A random-effects model was adopted when substantial heterogeneity was detected ($I^2 > 50\%$), reflecting expected variability across studies in terms of research design, VR applications, and contextual settings. Statistical heterogeneity was assessed using the Q statistic in combination with the I^2 index. Given the presence of heterogeneity exceeding the recommended threshold, subgroup analyses and meta-regression were conducted to identify potential moderators influencing communication effectiveness. Specifically, meta-regression analyses examined the effects of VR application type, audience composition, and characteristics of the sporting events covered. Together, these analyses provide a robust statistical evaluation of the communicative capacity of VR in sports journalism and its implications for future media practices.

To maintain analytical consistency and ensure replicability, a rigorous coding procedure was developed prior to data analysis. All included studies were subjected to a structured coding process based on a pre-defined codebook. Key variables coded from each study included: publication year, country of origin, type of VR intervention (e.g., 360-degree video, interactive VR), type of journalistic content (e.g., live sports, feature stories), study design (experimental, quasi-experimental, or cross-sectional), participant demographics, sample size, statistical outcomes (means and standard deviations), and extracted or calculated effect sizes. Two independent coders conducted the coding process. Inter-coder reliability was assessed using Cohen's kappa coefficient, which yielded a satisfactory agreement rate (κ=0.84). Discrepancies were resolved through consensus discussion or third-party arbitration.

RESULTS

A thorough assessment of how Virtual Reality (VR) benefits sports journalism arises from the comprehensive meta-analytical data. Across numerous studies, researchers systematically evaluated the impact of VR by

measuring its ability to enhance viewer immersion alongside interactivity and audience engagement. The results demonstrate that VR creates substantial positive user experiences, particularly as studies focusing on real-time event coverage and immersive athlete-perspective simulations yielded larger effect sizes. Heterogeneity tests indicated that research design and VR application types account for the observed diverse outcomes. Z-values were calculated as the ratio of the mean to the standard error and are utilized for descriptive comparison only; they do not represent the standardized effect sizes employed in conventional meta-analytic inference. These research findings provide deeper insights into how VR drives fundamental shifts in sports media and consumer behavior within media consumption.

Table 2. Descriptive Statistics for the Included Studies

Study Name	Mean	Standard Error	Variance	95% Confidence Interval (Lower)	95% Confidence Interval (Upper)	Z-Score
(Sundar，2017)	3.887	0.087	0.008	3.717	4.056	44.846
(Sung & Magnusen, 2017)	3.798	0.083	0.008	3.636	3.960	45.940
(Van Damme et al., 2019)	3.510	0.105	0.011	3.304	3.716	33.429
(Vettehen et al. 2019)	3.607	0.116	0.013	3.378	3.835	31.173
(Kunz & Santomier, 2020)	4.250	0.048	0.002	4.156	4.344	88.542
(Kang, 2020)	4.527	0.043	0.002	4.443	4.611	105.28
(Brivio et al., 2021)	4.167	0.240	0.058	3.697	4.637	17.360
(Kukkakorpi & Pantti, 2021)	4.120	0.078	0.006	3.967	4.273	52.671
(Antoine et al., 2022)	4.180	0.050	0.003	4.081	4.279	82.819
(Capasa et al., 2022)	4.250	0.076	0.006	4.100	4.400	55.683
(Meijer, 2022)	4.08	0.060	0.004	3.962	4.198	68.042
(Rosendahl et al., 2022)	4.220	0.050	0.003	4.122	4.318	84.024
(Nikolaou et al., 2022)	4.170	0.048	0.002	4.077	4.263	87.693
(Pérez-Seijo et al., 2022)	4.100	0.061	0.004	3.980	4.220	67.068
(Lima & Barbosa, 2023)	4.395	0.109	0.012	4.181	4.609	40.320
(Li et al., 2023)	4.120	0.058	0.003	4.007	4.233	71.387
(Choudhary & Sahu, 2023)	4.150	0.057	0.003	4.038	4.262	72.638
(Sun & Zhang, 2024)	4.150	0.046	0.002	4.060	4.240	90.675
(Chen, Hu & Fisher, 2024)	4.300	0.065	0.004	4.173	4.427	66.235
(Du, Wang, Wang, & Wang, 2024)	4.059	0.037	0.001	3.987	4.131	109.70

Study Name	Mean	Standard Error	Variance	95% Confidence Interval (Lower)	95% Confidence Interval (Upper)	Z-Score
(Talukdar & Yu, 2024)	4.050	0.046	0.002	3.959	4.141	88.043
(Greber et al., 2024)	4.050	0.067	0.005	3.918	4.182	60.105

The statistical findings from multiple studies regarding the impact of Virtual Reality (VR) in immersive journalism and sports-related news contexts are presented in **Table 2**. The table reports essential descriptive statistical measures, including mean values, standard errors, variances, confidence intervals, and Z-values, which together provide an overview of the consistency and precision of the reported outcomes across the included studies.

Overall, the reported mean values indicate generally positive evaluations of VR-based news experiences. Across the included studies, mean values range from 3.51 to 4.53, with the majority of estimates exceeding 4.0. Lower mean values are primarily observed in earlier studies, such as Sundar (2017) and Sung & Magnusen (2017), which examined early forms of immersive and 360-degree news formats. In this group, studies by Van Damme et al. (2019) and Vettehen et al. (2019) reported moderately positive mean values of 3.51 and 3.61, respectively, indicating favorable but less pronounced audience responses. In contrast, a substantial number of more recent studies report mean values clustered between 4.0 and 4.3, accompanied by relatively small standard errors. For example, Antoine et al. (2022), Li et al. (2023) and Nikolaou et al. (2022) reported mean values of 4.18, 4.12, and 4.17, respectively, with standard errors below 0.060. These results indicate that audience responses within these studies were closely concentrated around the reported means.

Variation in standard errors across studies reflects differences in study design and sample characteristics. While most studies report standard errors below 0.100, some studies exhibit larger values. Notably, Brivio et al. (2021) reported a standard error of 0.240, indicating greater dispersion in participant responses. Despite this variability, the corresponding confidence intervals across studies remain within a generally positive evaluation range. In studies focusing specifically on sports journalism and sports-related media contexts, relatively higher mean values are frequently observed. Kunz & Santomier (2020) and Kang (2020), for example, reported mean values of 4.25 and 4.53 respectively. These higher estimates are accompanied by confidence intervals that remain narrow relative to the scale range, indicating consistent audience evaluations in these studies.

Z-values further illustrate differences in the stability of reported estimates across studies. Across the dataset, Z-values range from approximately 17 to over 100. Studies with higher Z-values typically combine higher mean values with smaller standard errors, whereas lower Z-values are associated with larger standard errors and greater response variability. Taken together, the descriptive results summarized in **Table 2** document a pattern of generally positive audience responses to VR-based immersive journalism and sports-related news experiences, while also highlighting variability across studies in the magnitude and stability of reported outcomes.

Table 3. Meta-Analysis Results of the Study

Model		**Pooled mean estimates and 95% confidence intervals**				
Model	Number Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit
Fixed	22	4.150	0.002	0.000	4.126	4.155
Random effects	22	4.098	0.039	0.000	4.021	4.174

Model		**Heterogeneity**				**Tau Squared**	
Model	Number Studies	Q-value	df (Q)	P-value	I^2 (%)	Tau^2	Tau
Fixed	22	197.45	21	0.001	89.36	0.003	0.172

The **Table 3** presents the results from both fixed-effect and random-effects models used in the meta-analysis of 22 studies assessing the communicative effectiveness of virtual reality (VR) in sports journalism. Under the pooled mean estimates and confidence interval section, the fixed-effect model yielded a point estimate of 4.150 with a very small standard error (0.002), resulting in a narrow 95% confidence interval ranging from 4.126 to

4.155. This indicates a highly consistent and statistically significant overall effect across studies. In parallel, the random-effects model, which accounts for between-study variability, produced a slightly lower but closely aligned pooled estimate of 4.098, with a standard error of 0.039 and a 95% confidence interval extending from 4.021 to 4.174. The similarity between the fixed-effect and random-effects estimates suggests that the overall effect remains stable despite variability across study designs and research contexts.

In terms of heterogeneity, the Q statistic was 197.45 with 21 degrees of freedom, yielding a statistically significant p-value (p=0.001), indicating the presence of substantial heterogeneity among the included studies. This is further reflected in the I^2 value of 89.36%, suggesting that a large proportion of the observed variance is attributable to genuine between-study differences rather than sampling error. The estimated between-study variance (τ^2) was 0.003, corresponding to a Tau value of 0.172, which indicates meaningful dispersion in effect estimates across studies. Taken together, these findings indicate that while the pooled effect of VR-based sports journalism is consistently positive and robust, the magnitude of effects varies considerably across individual studies, supporting the appropriateness of the random-effects model for synthesizing the results.

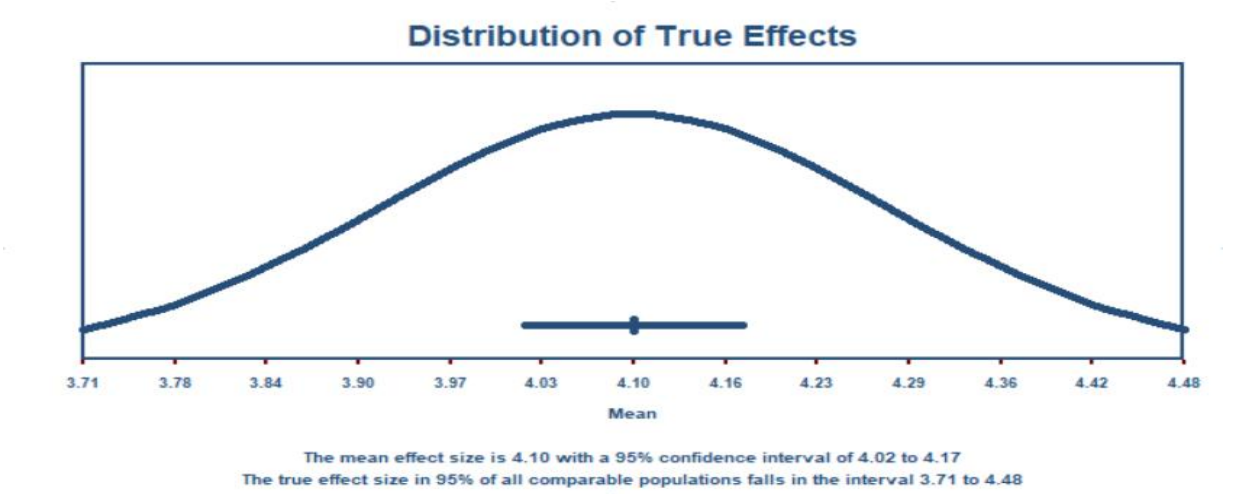

Figure 2. Distribution of True Effects Under the Random-Effects Model

To further illustrate the implications of the random-effects model, the distribution of true effects was examined. As shown in **Figure 2**, the pooled mean effect was estimated at 4.10, with a 95% confidence interval ranging from 4.02 to 4.17. The corresponding prediction interval suggests that the true effect size across comparable populations is likely to fall between 3.71 and 4.48, indicating substantial variability in audience evaluations across study contexts.

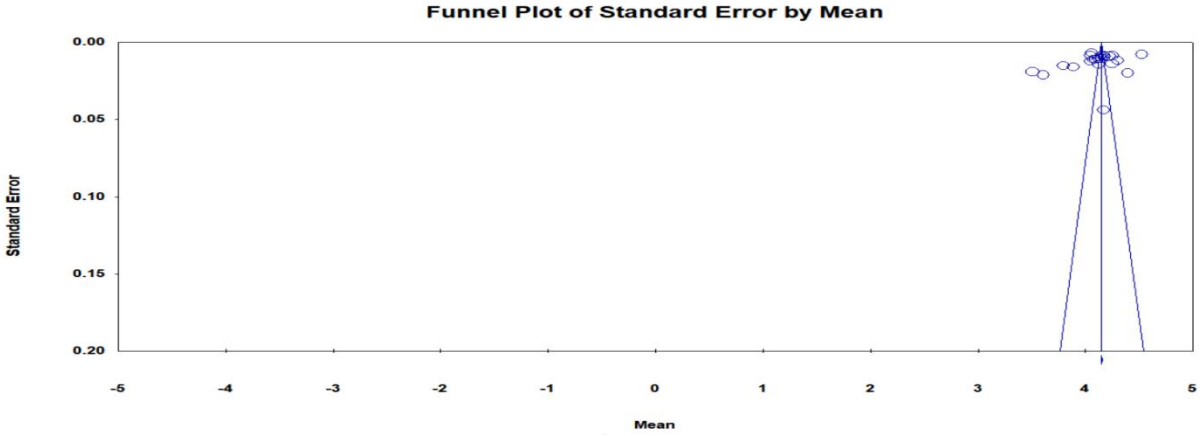

Figure 3. Funnel Plot of Standard Error by Mean

Figure 3 displays the relationship between the standard error and the mean effect size across studies included in the meta-analysis. Each open circle represents an individual study. The vertical line denotes the pooled mean effect size, while the diagonal lines indicate the pseudo 95% confidence limits. Overall, the studies

are tightly clustered around the pooled mean, reflecting relatively small standard errors across most included samples. Although the distribution appears concentrated on the higher end of the mean effect size, the narrow spread suggests consistent estimates across studies. This pattern may reflect underlying heterogeneity in study contexts rather than clear evidence of publication bias.

DISCUSSION

The findings of this meta-analysis provide empirical insight into the communicative potential of Virtual Reality (VR) in sports journalism, directly addressing the research questions. By synthesizing 22 empirical studies published between 2016 and 2024, the findings indicate that VR-based sports news is consistently evaluated positively in terms of immersion, sense of presence, and user engagement.

Regarding the first research question: how VR enhances immersion, interactivity, and audience engagement in sports journalism? Both the fixed-effects and random-effects models yield consistently high mean values.Under the random-effects model, the overall mean reaches 4.10, suggesting that audiences across diverse research contexts generally hold favorable attitudes toward VR sports news experiences. This aligns with prior research showing that immersive technologies such as 360-degree video and interactive VR environments significantly enhance spatial presence and emotional involvement (Sundar et al., 2017; Van Damme et al., 2019; Kunz & Santomier, 2020; Nikolaou et al., 2022; Talukdar & Yu, 2024). Through these affordances, VR enables audiences to move beyond traditional modes of sports media consumption and engage with content in more dynamic and experiential ways.

Furthermore, the results reveal substantial heterogeneity (I^2= 89.36%), indicating marked variation in the effects of VR across studies. This suggests that gains in immersion and engagement were closely tied to contextual factors, including the type of VR application, the nature of the sporting event, research design, and audience characteristics. Studies focusing on live events or event-driven sports coverage tend to report higher audience evaluations than those examining experimental or short-term experiences (Kang, 2020; Rosendahl et al., 2022; Capasa et al., 2022). These findings imply that the communicative advantages of VR are most pronounced when combined with the immediacy and emotional intensity inherent in sports content.

In response to the second research question concerning the broader communicative potential of VR in sports journalism, the findings suggest that VR extends the boundaries of traditional news dissemination by enabling experiential rather than purely passive forms of news consumption. Multiple studies emphasize that VR shifts audiences from passive viewing toward exploratory participation, allowing users to experience sports events from multiple perspectives (Vettehen et al., 2019; Meijer, 2022; Pérez-Seijo et al., 2022). This shift strengthens emotional resonance and audience involvement, which are pivotal elements of the sports media experience. The key strength of VR lies in its capacity to let audiences “experience” news events, rather than merely watch or read about them (Choudhary & Sahu, 2023). Such immersive affordances resonate deeply with the inherently affective and participatory nature of sports journalism (González & Serra, 2024).

Nevertheless, the analysis also highlights limitations within the existing evidence base. Although most studies report positive short-term audience responses, there is a notable lack of research on the long-term communicative effects of VR in sports journalism, particularly with respect to sustained engagement, information retention, and changes in news consumption behavior (Van Damme et al., 2019; Meijer, 2022; Sun & Zhang, 2024). Some studies caution that heightened immersion does not necessarily translate into improved information processing or deeper understanding of complex sports narratives(Brivio et al., 2021; Du et al., 2024). In certain cases, excessive sensory stimulation may compete with cognitive resources, thereby constraining the effectiveness of VR for conveying complex information(Vincent& Frewen, 2023). Further challenges relate to technological accessibility, production quality, and user comfort. Variations in VR hardware, production standards, and user familiarity with immersive technologies may contribute to the dispersion of results across studies (Kukkakorpi & Pantti, 2021;Brivio et al., 2021; Pérez-Seijo et al., 2022). These findings suggest that the communicative value of VR in sports journalism depends less on the technology itself than on its implementation, production quality, and accessibility.

In sum, the results of this meta-analysis confirm the communicative potential of VR in sports journalism, while underscoring its conditional nature. VR is particularly effective in enhancing audience immersion and engagement when its affordances align with the intrinsic characteristics of sports reporting. However, broader adoption will depend on addressing technological, cognitive, and ethical constraints. Future research should move beyond short-term assessments, examine VR in comparison with traditional sports media formats, and develop standardized metrics for evaluating the communicative effects of immersive journalism.

CONCLUSION

Overall, the meta-analytic findings indicate that Virtual Reality can enhance communication effectiveness in sports journalism. Across the reviewed studies, VR-based sports news is generally associated with more positive audience responses than conventional reporting formats, particularly with regard to immersion, perceived presence, and user engagement. Taken together, these results suggest that immersive technologies offer clear communicative advantages and hold potential for enriching how sports stories are experienced and understood.

At the same time, the findings reveal that the effectiveness of VR in sports journalism is far from uniform. The substantial heterogeneity across studies points to a strong dependence on contextual and design-related factors, including the type of sporting event, the production quality of VR content, and audience characteristics. Shown most clearly in contexts where immediacy, emotional intensity, and experiential involvement are central, VR appears to be especially effective when its immersive affordances align with the core qualities of sports reporting. Under such conditions, VR facilitates more engaged and emotionally resonant audience interactions with sports news.

The analysis also highlights several limitations in the current research landscape and in journalistic practice. While short-term audience responses to VR sports journalism tend to be positive, empirical evidence on long-term communicative outcomes remains scarce. Issues such as sustained engagement, information retention, and changes in news consumption behavior have not yet been systematically examined. In addition, technological accessibility, production costs, user comfort, and ethical considerations continue to constrain the broader adoption of VR within sports journalism practice. These issues highlight the need for for a cautious and reflective approach to integrating immersive technologies into journalistic workflows.

In conclusion, this meta-analysis demonstrates that Virtual Reality holds meaningful promise for advancing sports journalism, but its impact is shaped by context and implementation. Rather than replacing traditional forms of sports reporting, VR is best understood as a complementary journalistic resource that can expand storytelling possibilities when applied appropriately. Future research should therefore prioritize long-term audience effects, direct comparisons with established media formats, and the development of shared standards for evaluating immersive journalistic practices.

Implications

The findings of this study highlight significant implications for the integration of Virtual Reality (VR) technology in sports journalism. The results suggest that the use of immersive storytelling strategies can enhance the communicative effectiveness of sports reporting, particularly in the context of real-time sports broadcasting. The integration of 360-degree video, interactive commentary, and athlete-produced content through VR appears to support higher levels of audience engagement, without positioning VR as a direct replacement for conventional forms of sports journalism.

In addition, the wide range of observed effect sizes indicates that the communicative effectiveness of VR is not uniform and depends on several contextual factors, including access to technology and levels of digital literacy. These findings suggest that sports media organizations should prioritize usability when developing VR applications and provide appropriate guidance to help users navigate virtual environments. Such efforts may help reduce barriers to adoption and improve audience experiences with immersive sports news. The findings also point to important ethical and normative considerations. Issues related to data privacy, content authenticity, and user comfort remain central to maintaining journalistic credibility and public trust in VR-based sports journalism. Addressing these concerns is therefore essential for the responsible integration of immersive technologies into journalistic practice.

From a research perspective, the results highlight the need for additional studies that report neutral or negative outcomes, as publication bias may shape the current body of evidence. There is also a need for more standardized research designs to examine the long-term effects of VR on audience engagement, trust in media sources, and information evaluation practices. Meanwhile, closer collaboration among key stakeholders in sports journalism, including broadcasters, journalists, and technology developers, may support the sustainable implementation of VR in digital sports media. When technical, ethical, and practical challenges are adequately addressed, VR may contribute to meaningful changes in how sports news is produced, communicated, and experienced.

Limitations and Future Research Recommendations

This study, while offering some insights into the communicative potential of VR in sports journalism, faces

several limitations that should be acknowledged. First, the meta-analysis revealed substantial heterogeneity (I^2= 89.36%), indicating that effect sizes vary considerably across studies. This variability stems from differences in study designs, types of VR content, audience demographics, and technological implementations. Consequently, the generalizability of the findings is constrained by inconsistent methodological frameworks across the included studies. In addition, most of the primary studies examined short-term effects of VR experiences, such as immediate engagement and interactivity. As a result, the long-term influence of VR on audience retention, trust in journalism, and information processing remains under-explored. Future research would benefit from adopting longitudinal designs to assess the sustained communicative impact of VR-based sports journalism over extended periods.

Second, despite efforts to minimize publication bias, the asymmetrical distribution of effect sizes suggests a potential underreporting of neutral or negative findings. This selective visibility may lead to an overestimation of the overall effectiveness of VR in sports journalism. To address this issue, future meta-analyses should incorporate unpublished studies and gray literature, while promoting greater transparency in reporting all research outcomes. Third, the scope of this study was restricted to English-language publications, thereby excluding relevant research indexed in major non-English regional databases, such as the China National Knowledge Infrastructure (CNKI), the Scientific Electronic Library Online (SciELO), and CiNii (Scholarly and Academic Information Navigator), among others. Consequently, insights from diverse non-English academic contexts remain underrepresented. Future reviews should therefore consider incorporating multilingual databases to provide a more comprehensive and globally representative understanding of VR applications in sports journalism.

Finally, accessibility challenges related to VR, such as hardware costs and disparities in digital skills, were not directly examined in this study but remain critical factors influencing adoption and use. Ethical issues including data privacy, immersive manipulation, and content accuracy were also beyond the scope of the present meta-analysis but are increasingly relevant in immersive journalism. Future empirical research should therefore examine how accessibility barriers and ethical considerations shape audience experiences with VR-based sports journalism, and develop evaluation frameworks to support the responsible and inclusive integration of immersive technologies in sports media.

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