

Review paper

EXPLORING THE IMPACT OF NEW TECHNOLOGIES ON SPORT TOURISM: A COMPREHENSIVE REVIEW

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Abstract

Introduction. New technologies have emerged as promising avenues for enriching sport tourism experiences by immersing participants in virtual environments. By synthesizing existing literature, the study seeks to unveil the potential benefits and challenges associated with incorporating different types of virtual realities into sport tourism settings. **Material and Methods.** The analysis, based on studies from Scopus and Web of Science, employed frequency analysis and thematic modeling, proving effective in identifying high-frequency keywords. A thematic evolution map highlighted relationships and categorized keywords into motor, niche, basic, and emerging or declining themes. This clustering revealed predominant themes in the literature on new technologies in sport tourism. **Results.** Throughout the review, three key clusters surrounding the fusion of new technologies with sport tourism are identified, (1) management and marketing strategies, (2) engagement, and (3) device innovation. **Conclusions.** Virtual reality is recognized as the leading technology in sport tourism within the scientific literature, while consumer-focused research and technology innovation studies are identified as key areas for future research.

Keywords: new technologies, sport tourism, management and marketing strategies, engagement, device innovation

Introduction

The convergence of new technologies in tourism is leading to transformative changes in how tourists engage with destinations and experiences. New technologies allow participants to engage with their favourite sports in new and exciting ways, ranging from non-immersive to fully immersive experiences [1, 2]. These innovations improve accessibility and enjoyment, revolutionizing the entire sport tourism ecosystem [3]. New technologies enable unprecedented performance, data-driven decision-making, and compelling user experiences [4, 5].

The sport tourism landscape has seen a remarkable integration of cutting-edge technologies. As a rapidly growing sector, it stands to benefit significantly from these new technologies, enriching sport tourism experiences by immersing participants in virtual environments [6]. Early research in the 1990s explored VR for sports training and simulations, reducing the need for physical travel [7, 8]. Recent studies show that integrating technology into sports venues enhances spectator experiences and supports a holistic approach to sport tourism [4, 9]. Technologies like mobile apps, VR (Virtual reality), and AR (Augmented reality) improve the customer experience in sport tourism, though further validation is needed for real vs. virtual tasks [10, 11]. Interactive systems and wearable technologies in sport tourism increase participation by making physical activities more enjoyable, improving competition fairness, and making experiences more engaging for participants and spectators [12, 13, 14, 15]. These technologies offer real-time feedback, track progress, and gamify exercise experiences, motivating individuals to stay active and engaged [16, 17]. Their application includes executing events amid globalization and digital innovation [18], identifying trends [19], exploring E-sport tourism [20], and utilizing technology in the pre/during/post phases of travel [21].

Immersive and new technologies are frequently perceived as synonymous. According to Slater [22], immersive technology gives high-quality or abundant sensory information. New technology encompasses the latest digital gadgets and software to improve efficiency, usefulness, and accessibility [23], including VR, AR, Mixed reality (MR), and Extended reality (XR) [24, 25], the Internet of Things (IoT) [26], and Artificial intelligence (AI) [27].

VR provides a fully immersive experience, allowing tourists to engage in sporting activities virtually [1, 28] by increasing vividness, interactivity, and telepresence, especially for less involved fans [29]. MR creates a more immersive experience by mixing real and virtual surroundings and complementing the real world with digital features [30, 31]. Virtual and augmented components in MR boost immersion, revolutionizing athlete training, fan engagement, and broadcasts [32]. AR improves engagement and interaction by adding digital information to the actual environment [33]. It provides interactive replays, data visualization, and personalized content by overlaying photos, movies, and 3D models on events and destinations in real time [34, 35, 36, 37, 38]. The burgeoning field of XR, including VR, AR, and MR, has revolutionized sport tourism by enhancing sports enthusiast experiences [39, 40]. IoT improves event monitoring, management, and efficiency, enhancing experiences for participants and spectators [26] referring to a network of physical devices connected to the internet, which collect and share data. IoT enables operators to enhance service delivery, optimize operations, and provide personalized experiences [41]. These devices include sensors, cameras, smart appliances, and other internet-connected tools. Combined with big data and AI, IoT offers insights to optimize training, event management, and marketing strategies, reshaping the sport tourism landscape with innovative experiences. According to Russell and Norvig

[42], AI is intelligent agents that enable data-driven insights and decision-making [36]. AI gives sports teams a competitive edge by personalising training programmes, analysing performance data, and providing real-time feedback [43]. The convergence of VR, AR, XR, MR, AI, and IoT has the potential to redefine how tourists experience, analyse, and engage with sports, ushering in a new era of transformative innovation during travel [44, 45]. Understanding the most widely used sport tourism technologies is vital for driving innovation and upgrading the visitor experience as technologies change.

While there has been considerable research of VR and AR in hospitality [46, 47], there is a notable lack of comprehensive reviews synthesizing the various technologies used in sport tourism. Researchers have referenced a range of technologies, including immersive technologies, smart equipment, and connected fitness devices. Notable literature reviews include Milasi et al. [48], who examine IoT applications in sports and tourism, Muniz-Pardos et al. [49], who explore new technologies at the Tokyo 2020 Olympics, or Nikas and Poulaki [50], who investigate eSports tourism. However, existing research tends to focus on individual technologies or specific applications rather than providing a holistic overview.

This study aims to address this gap by exploring:

RQ1: What are the key themes associated with the application of new technologies in sport tourism?

RQ2: What are the most prevalent new technologies currently being utilized in sport tourism?

RQ3: What are the main directions for future research of new technologies in sport tourism?

By addressing these questions, this study aims to ensure a comprehensive understanding of the technological advancements within this field.

Material and methods

Searching procedure

Building on the statement by Wong et al. [51], a comprehensive overview of the literature facilitates the delineation of key challenges in creating connections through various components. Previous comprehensive literature reviews highlighted the significance of keywords in addressing research topics [52, 53]. This analysis facilitated a topic modelling through keyword research. The advantages of this methodology have been acknowledged and described in an earlier study by Kim and Kim [54], whose protocol was followed to answer what are the primary bibliometric characteristics of the literature and what are the most common areas of application of new technologies in the specific field of sport tourism.

The databases Scopus and Web of Science (WoS) were used for the search. Visser, et al. [55] found that Scopus and WoS complement each other by providing comprehensive coverage of the scientific literature and flexible filtering options to select relevant literature. After selecting the publisher, a detailed search for documents using specific keywords was conducted. The search terms included sport(s), travel, tourism, virtual reality, mixed reality, augmented reality, extended reality, artificial intelligence, Internet of Things, and new technologies. Boolean operators AND and OR and corresponding truncations (*) were used to identify relevant papers that included different versions of these terms. The search focused on articles, books, book chapters, reviews, and proceeding papers within the subject areas of economics, econometrics, finance, management, and accounting. Only English-language papers were included. The search was conducted in July 2024 without any time restrictions.

The process of selecting studies included in the research is illustrated in Figure 1. The initial search yielded a total of 439 records. Specifically, 115 records were found in Scopus, while the WoS database initially identified 324 records. For identifying the duplicates, Mendeley software was used resulting in 17 duplicate articles. After removing the duplicates, the abstracts of 422 articles were screened twice, resulting in the removal of 233 articles. Studies were excluded if they did not incorporate key themes related to the integration of new technologies with sport tourism or travel. After this screening process, 189 full-text articles were deemed relevant and were subsequently assessed for eligibility in the next phase. The identification resulted in 48 records that represented the intersection of sport tourism and new technologies in sports. To ensure comprehensiveness, the broader keyword tourism was used to include records on new technologies that could be applied to tourism purposes, even if they were not directly related to travel. Out of a total of 48 documents, 46 were quantitative research papers, while only two were based on qualitative research. According to Paul and Criado [56], a literature review can be created using from 40-50 to over 500 pertinent papers.

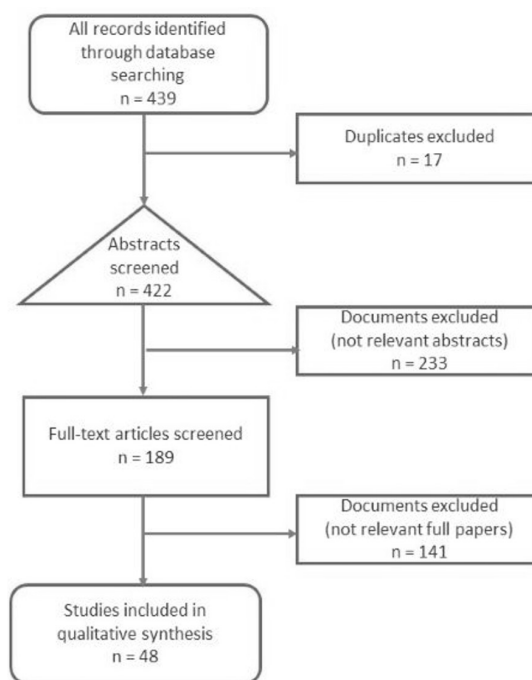


Fig. 1. Prisma diagram

Sample description

The sample comprises an increasing number of articles in recent years, with the majority being published recently (Fig. 2). In 2024 and 2023, there were nine articles published each, while in 2022 there were eight articles. Six articles were published in 2021 and five articles in 2020. For the remaining years, three articles were published in 2019, two articles were published in 2015, while all other years saw only one article each (2018, 2017, 2016, 2014, 2013, and 1999). The research focus within the field of new technologies in sport tourism is primarily VR, with a total of 24 studies accounting half of all papers. The IoT is the second most prominent area with twelve studies. AR ranks third with eight articles. XR is covered by two studies, while MR and AI are addressed by one study each.

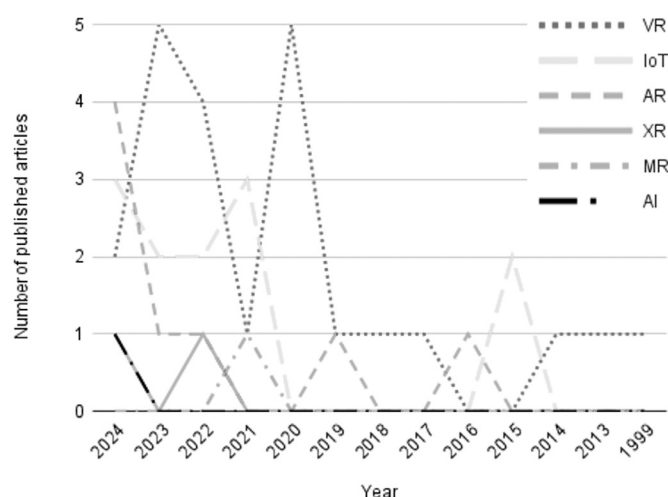


Fig. 2. Timeline of published articles per type of technology

The pioneering study of virtual reality in sport tourism was conducted by Kurtzman and Zauhar [8], who were the first to explore VR's potential in this field. The most relevant authors include Kim E., Lei W., Ngan H., and Perić, M., each contributing two significant documents to the field. The leading countries for corresponding authors are China (Sun Yat-sen University), the United Kingdom (Brighton University), and Germany (University of Cologne). The most relevant sources are the *Sport in Society* journal, with four articles, followed by *Information Technology & Tourism* journal, *Journal of Sport and Tourism*, *Leisure Sciences*, and *International Journal of Grid and Utility Computing* journal, each with two published articles.

Text analysis

In the final analysis phase, frequency analysis and thematic modelling were conducted using NVivo software, which has been shown to be highly effective for frequency analysis [57], and Bibliometrix for thematic modelling. The analysis was conducted on the entire set of articles, offering a comprehensive overview of the data and categorizing the articles into various sport-related themes. The word frequency analysis examined terms that appeared 50 or more times in selected papers, identifying the top 20 most frequent words. The search terms such as research, study, data, online, new, are excluded to avoid skewing the results with terms that are ubiquitous but not specific to the study's focus.

A thematic evolution map was created to identify relationships with keywords. By comparing frameworks across the highest-frequency keywords, the authors examined if themes sharing the same name were connected with the same keywords. To identify these themes, the coding feature was activated, finalizing the theme and sub-theme identification. Two authors independently performed the coding to avoid bias. To better understand the automatically generated key themes, a thematic map was utilized to identify and analyze connections between various topics.

The software identified key groups of high-frequency words categorized into motor themes, niche themes, basic themes, and emerging or declining themes. Motor themes are crucial for understanding and developing the research field, representing core topics that drive the research area forward. Niche themes represent specialized areas of research that are well-explored but do not significantly influence the broader field, making them important for experts in specific subfields. Emerging the-

mes are new areas of research gaining interest and have the potential to become more central in the future, while declining themes are losing relevance and may eventually disappear from the research field. Basic themes are essential for the structure of the research field, providing the groundwork upon which other research builds.

Based on the relevance and relationships of these extracted themes, the authors suggested further grouping. By organizing the initial themes according to their connected keywords, new primary clusters were extracted, providing a clearer and more cohesive understanding of the core areas within the field. Particular focus was given to themes that repeatedly appeared within sub-themes. After conducting the thematic modeling, the clusters were organized around the central sub-themes unique to VR, AR, MR, XR, IoT, and AI. A detailed overview was then created to illustrate how each technology aligns with these sub-themes. Based on the identified key clusters, propositions and directions for further research were provided to guide future studies.

Results

Frequency analysis

The frequency analysis reveals that terms related to user engagement and experience are the most prevalent. The top ten terms include participant (1061 mentions), experience (1051), communication (1032), social (1030), management (974), fans (952), game (942), interaction (834), development (799), and consumer (771) (Fig. 3). Other prominent terms are team (648), system (622), and physical (560). This analysis shows a strong focus on individuals interacting with new technologies in sport tourism, that is, the roles and experiences of people engaging with technological innovations.



Fig. 3. Word frequency cloud

Studies primarily explore wearable technologies, focusing on user involvement and experiences [5, 58, 59, 60]. The term participant often refers to fans [5, 61], consumers [62], players [63], and spectators [58], highlighting research on human interaction with technology.

The terms experience, communication, system and game are frequently found, emphasizing how participants interact and exchange information while using virtual technologies [64]. Experience illustrates user interaction with technologies [5, 60], while communication underscores the importance of information exchange between participants and devices [59, 61].

Terms such as management and model relate to the technologies used in sports and their management [58, 65]. Management often involves organizing sports events [5, 58], and

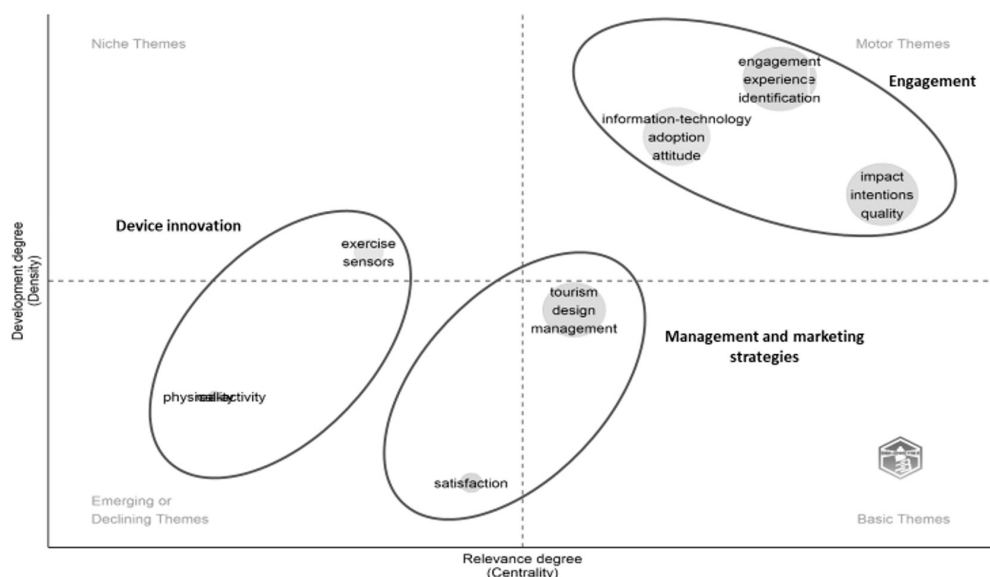


Fig. 4. Thematic Map

understanding intention formation when implementing new technologies [60, 66]. Interaction, performance, and team are related to marketing activities, particularly in the context of presumption, where fans act as both producers and consumers [5]. The concept of the team itself can be leveraged in marketing to build a sense of identity and belonging among fans, encouraging them to actively participate in content creation and promotion.

The rise of eSports presents significant marketing opportunities and challenges, such as potential integration into traditional sports structures like the Olympics [67]. Adopting new technologies enables sports organizations to offer personalized and immersive experiences, thereby enhancing fan engagement and loyalty. This fusion of physical and virtual realities opens new marketing avenues, including virtual sponsorships and augmented reality promotions, which expand the reach and impact of marketing in sport tourism.

Overall, the literature addresses user experience, communication, and the technical and managerial aspects of integrating new technologies into sport tourism. The emphasis on information and system underscores the importance of technological frameworks and data management in enhancing sports experiences and operational efficiencies. Studies by Stodolska et al. [63], Sjöblom et al. [68], and Turner [69] explore the differences between virtual and physical reality, providing insights into their distinct characteristics and applications.

Thematic modelling

Seven key themes were extracted from the coding process (Fig. 4). The motor themes include (1) engagement, experience, identification, (2) information-technology adoption, attitude, and (3) impact, intentions, quality. These themes are crucial for developing the research field and represent core topics. They involve the active participation of researchers, practitioners, and participants, fostering meaningful experiences and identification with the field. Niche themes include (1) exercise and sensors. These themes have high density but lower centrality, indicating they are well-developed specialized areas with significant research but less influence on the broader field. Exercise research offers insights into health and fitness, while sensors provide advanced technological applications. However, these

themes are not as widely applicable as engagement or information-technology adoption.

Emerging or declining themes consist of (1) physical activity and (2) satisfaction, show low centrality and low density, suggesting it is either an emerging or declining area of interest. Physical activity research explores impacts on health and behavior, while satisfaction studies look at user experiences. These themes require more comprehensive studies to establish their importance. Basic themes including (1) tourism, design, and management, have high centrality but lower density, indicating they are fundamental and widely discussed in the field but not deeply explored. This theme involves the organization and covers the planning and creation of products, services, and experiences.

Themes are subsequently merged into three broader clusters (Fig. 4), showing the interconnection and influence among them. Merging themes into clusters does not mean they are unrelated, but simply that their analysis importance is reduced. Exercise, sensors, physical activity, and reality are grouped in the device innovation cluster across niche and declining/emerging themes quadrants because they contribute to specialized knowledge about physical health and fitness. For instance, physical activity and reality in device innovation is less developed than exercise (i.e., with lower density and centrality) and focuses on how new technologies and devices can improve physical health and performance. Physical activity is on the rise, representing a growing area of interest. Technology promises to improve sport tourism for professionals and leisure athletes by making exercise more enjoyable and tailored.

Tourism, design, management, and satisfaction are grouped together in the management and marketing strategies cluster. It is spread across basic and emerging/declining themes quadrants. These themes are likely clustered due to their frequent co-occurrence in studies focusing on marketing and development strategies. This category encompasses the planning, execution, and evaluation of marketing efforts. Integrating satisfaction with tourism, design, and management improves user experiences and outcomes, which are crucial for marketing and development strategies. Engagement, experience, identification, information-technology adoption, attitude, impact, inten-

tions, and quality are merged into the engagement cluster. It is fully situated within the motor themes quadrant. The themes within this cluster are grouped together due to their frequent co-occurrence in studies focused on user engagement and technology adoption. These themes emphasize active participation, which creates meaningful experiences and a strong field identity.

The analysis further demonstrates how the various clusters interconnect with VR, AR, XR, MR, IoT, and AI, along with their respective sub-themes. Each technology presents unique opportunities and challenges, contributing to the categorization of papers, which highlights the diverse applications and key findings of new technologies in sport tourism through key sub-themes.

Management and marketing strategies

Papers on marketing strategies and development emphasize creating innovative approaches to promote sport tourism and enhance user engagement. These strategies ensure effective use of technologies to meet market demands and drive growth, highlighting the importance of boosting audience engagement and retention. Management and marketing strategies, as presented in Table 1, are dominant in VR (thirteen sub-themes), IoT and AR (six sub-themes each), XR (three sub-themes), and AI (one sub-theme). Prevalent indicates articles where marketing is the dominant theme, but subtopics also engage with user engagement and device innovation.

Table 1. ANCOVA results for balance variables

Technology type	Sub-theme	Source
VR	Event promotion and management	Davis & Gibbons [5]; Petit et al. [62]; Aghey [67]; Sjöblom et al. [68]; Capasa et al. [70]; Helsen et al. [71]; Qian et al. [72]
	Marketing strategy to enhance the experience and satisfaction	Cardoso & Almeida [59]; Capasa et al. [70]; Qian et al. [72]; Cheeyong et al. [73]
	Information technology adoption in sport tourism management	Kurtzman & Zauhar [8]; Sjöblom et al. [68]; Pashaie & Perić [74]
	Demand factors and consumer culture	Davis & Gibbons [5]; Qian et al. [72]
	Physical vs. virtual environment and hybrid events	Davis & Gibbons [5]; Woyo & Nyamandi [75]
	Behavioural change, control, intention and attitude	Han et al. [66]; Helsen et al. [71]
	Implications for event organizers	Aghey [67]; Helsen et al. [71]; Thompson et al. [76]
	Value co-creation and customer needs	Qian et al. [72]; Ratten & Jones [77]
	Strategy related entrepreneurship	Petit et al. [62]; Ratten & Jones [77]
	Sponsorship	Petit et al. [62]
	Trend analysis	Tu & Hwang [78]
	External factors	Helsen et al. [71]; Pashaie & Perić [74]
	Economic, sociocultural, and environmental perspectives	Pashaie & Perić [74]; Thompson et al. [76]
IoT	Integration of sports and tourism with new technologies	Milasi et al. [48]; Hu et al. [79]; Perez-Aranda et al. [80]; Tang [81]
	Event promotion and management	Muniz-Pardos et al. [49]; Agnes et al. [58]; Achilleos et al. [82]; Leou et al. [83]
	Value co-creation and customer consumption needs	Tang [81]
	Emerging role of IoT in sports	Leou et al. [83]
	Social identity	Zeng et al. [84]
	Technology readiness (TR)	Huang et al. [85]
AR	Event promotion and management	Glebova et al. [65]; Bustard et al. [86]; Pu et al. [87]
	Visit/revisit intentions and satisfaction	Song & Kim [60]; Lei & Ngan [88]; Ngan & Lei [89]
	Value co-creation and customer needs	Uhrich et al. [61]
	Behavioural change and intentions	Song & Kim [60]
	Trend analysis	Lei & Ngan [88]
	Smart event experience	Bustard et al. [86]
XR	Integration of sports and tourism with new technologies	Langaro et al. [90]
	Predictors of technology adoption	
	Information technology adoption in sport tourism management	Liu et al. [91]
MR	/	/
AI	Integration of sports and tourism with new technologies	Huang & Yang [92]

The thematic analysis revealed that management and marketing strategies in VR encompass 13 sub-themes contributing to advancements in sport tourism (e.g., Sjöblom et al. [68]; Pashaie & Perić [74]), the impact of technology and new media (e.g., Qian et al. [72]), and technological advancements in VR (e.g., Thompson et al. [76]). These sub-themes explore how new technologies can promote the future of sport tourism.

Notable sub-themes include event promotion and management, present in VR, IoT, and AR, and appearing in 7 articles (e.g., Davis & Gibbons [5]; Petit et al. [62]). It highlights the use of new technologies in promoting and organizing events and factors influencing participants to attend. Marketing strategy to enhance the experience and satisfaction, present in 4 articles (e.g., Cardoso & Almeida [59]; Capasa et al. [70]), is exploring customer experiences with new technologies, their needs, expectations, and interactions with devices for marketing and business development. Information technology adoption in sport tourism management discussed in 3 articles (e.g., Sjöblom et al. [68]; Pashaie & Perić [74]) explores the role of new technologies in enhancing tourism management.

Other sub-themes like demand factors and consumer culture (e.g., Davis & Gibbons [5]) and behavioral change, control, intention and attitude (e.g., Helsen et al. [71]) investigate consumer behavior and decision-making processes, providing insights into active consumer participation and behavioral control. Physical vs. virtual environment and hybrid events (e.g., Davis & Gibbons [5]) emphasize the experience of participating in on-site and online events. Event-related research is prominent, with 15 out of 48 articles focusing on events, highlighting their role in exploring new technologies for marketing purposes. Demand factors and consumer culture [72] explore online spectator demand, while value co-creation and customer needs (e.g., Ratten & Jones [77]) develop a framework for value co-creation through technology-supported interactions.

Management-oriented sub-themes include strategy related entrepreneurship (e.g., Ratten & Jones [77]) focusing on incorporating emerging technologies in the global business environment. Economic, sociocultural, and environmental perspectives of sport tourism (e.g., Pashaie & Perić, [74]) propose a model for the future of sport tourism post-Covid-19.

In IoT, the most prevalent sub-themes are integration of sports and tourism with new technologies and event promotion and management, each appearing in four articles. They focus on integrating technology into sports marketing strategies and event management. Other sub-themes like value co-creation and customer consumption needs, emerging role of IoT in sports, social identity, and technology readiness illustrate how a deep understanding of consumer behavior, technological integration, and social identity can significantly enhance marketing strategies and management practices in sport tourism, leading to more effective and engaging approaches.

In AR, two dominant sub-themes are event promotion and management and visit/revisit intentions and satisfaction, exploring AR's role in enhancing visitor experiences and attendees' intentions to revisit events. Satisfaction is emphasized as a critical factor, as it directly impacts the likelihood of attendees returning to events. Other sub-themes like behavioral change and intentions, and smart event experience investigate participants' behavior and interactions, trend analysis [88] provides literature reviews on trends and research issues in mobile learning within hospitality, leisure, sport, and tourism.

In XR, sub-themes like integration of sports and tourism with new technologies and predictors of technology adoption explore technology's potential in revolutionizing the soccer in-

dustry and enhancing fan experiences. Information technology adoption in sport tourism management examines immersive technology stimuli for tourism experiences. By focusing on these sub-themes, marketing efforts can effectively communicate the benefits and innovations brought by XR technologies, thereby enhancing fan engagement, attracting new audiences, and promoting the advanced capabilities of sport tourism management.

In AI, the theme integration of sports and tourism with new technologies [92] emphasizes the benefits of AI in sports and tourism. It highlights AI's usability, innovative potential, and developmental impact, showcasing how AI enhances experiences and drives growth in these sectors.

Engagement

Papers focused on user experiences strengthen connections between players and fans, ensuring technologies meet user needs and expectations. This cluster also highlights immersive experiences' role in attracting and retaining audiences. Table 2 shows that engagement is present in VR (ten sub-themes), AR (six sub-themes), IoT (four sub-themes) MR (two sub-themes), and XR and AI (one sub-theme each).

Spectator/fan experience (e.g., Stodolska et al. [63]; Capasa et al. [70]) and intentions for integration, expectancy and experience (e.g., Sjöblom et al. [68]; Capasa et al. [70]), present in VR, IoT, and AR, explore active and passive participation in physical and virtual sports events, and factors motivating technology use. Consumer acceptance (e.g., Westmattmann et al. [99]) found in MR, and AI, examines how consumer interactions shape the adoption of new technologies. Online vs offline and hybrid experience (e.g., Cardoso & Almeida [59]; Woyo & Nyamandi [75]) compare online spectating with live attendance, emphasizing the flow experience's role in engagement. Infrastructure for interaction, dominant across all technologies except AI, deals with the technologies enhancing participant communication and user perception.

Other significant sub-themes include emotional and sensory engagement (e.g., Petit et al. [62]; Stodolska et al. [63]) and training environment and experience (e.g., Gulec et al. [94]). These emphasize creating rich, immersive experiences that emotionally and physically stimulate users. Fan culture and identification (e.g., Cardoso & Almeida [59]) explore how new technologies reshape events and foster community among fans. Quality of life [63] highlights how participation in activities using new technologies fosters overall well-being and life satisfaction.

The analysis in IoT shows that infrastructure for interaction (e.g., Milasi et al. [48]) integrates smart infrastructure and advanced technological tools to enhance spectator experiences. Spectator/fan experience (e.g., Agnes et al. [58]; Cairns [96]), and interactive involvement [83] focus on how new technologies transform sports activities and fan engagement, while intentions for integration, expectancy and experience [84] ensure technological advancements meet user expectations and create satisfying experiences.

In AR, sub-themes include infrastructure for interaction (e.g., Song & Kim [60]; Lei & Ngan [88]) and intentions for integration, expectancy and experience (e.g., Pu et al. [87]; Ngan & Lei [89]), similar to VR and IoT, focusing on impacts on activities, spectatorship, and fan engagement. Cognitive engagement [84] describes mental involvement in activities using virtual reality technologies. In XR, the infrastructure for interaction (e.g., Langaro et al. [90]) sub-theme explores technology's potential to enhance home-watching experiences for fans. In MR, infra-

Table 2. Engagement papers categorization to key sub-themes and new technology types

Technology type	Sub-theme	Source
VR	Spectator/fan experience	Zhao & Guo [36]; Stodolska et al. [63]; Chang et al. [64]; Turner [69]; Capasa et al. [70]; Cheeyong et al. [73]; Tu & Hwang [78]; Yang [93]
	Infrastructure for interaction	Stodolska et al. [63]; Chang et al. [64]; Woyo & Nyamandi [75]; Gulec et al. [94]
	Online vs offline and hybrid experience	Cardoso & Almeida [59]; Sjöblom et al. [68]; Turner [69]; Woyo & Nyamandi [75]
	Emotional and sensory engagement	Kurtzman & Zauhar [8]; Petit et al. [62]; Stodolska et al. [63]
	Training environment and experience	Petit et al. [62]; Helsen et al. [71]; Gulec et al. [94]
	Intentions for integration, expectancy and experience	Sjöblom et al. [68]; Capasa et al. [70]; Kunz & Santomier [95]
	Impact of audience and technology on events	Sjöblom et al. [68]; Turner [69]
	Fan culture and identification	Cardoso & Almeida [59]; Turner [69]
	External factors	Chang et al. [64]
	Quality of life	Stodolska et al. [63]
IoT	Infrastructure for interaction	Fu [4]; Milasi et al. [48]; Hu et al. [79]; Achilleos et al. [82]; Cairns [96]; Zhang & Breedlove [97]
	Spectator/fan experience	Agnes et al. [58]; Cairns [96]
	Intentions for integration, expectancy and experience	Zeng et al. [84]
	Interactive involvement	Leou et al. [83]
AR	Infrastructure for interaction	Song & Kim [60]; Uhrich et al. [61]; Glebova et al. [65]; Bustard et al. [86]; Lei & Ngan [88]
	Intentions for integration, expectancy and experience	Pu et al. [87]; Ngan & Lei [89]; Gavril-Alexandris & Vakalakis [98]
	Online vs offline and hybrid experience	Pu et al. [87]; Gavril-Alexandris & Vakalakis [98]
	Impact of flow experience	Song & Kim [60]
	Spectator/fan experience	Glebova et al. [65]
	Cognitive engagement	Ngan & Lei [89]
XR	Infrastructure for interaction	Langaro et al. [90]; Liu et al. [91]
MR	Infrastructure for interaction	Westmattmann et al. [6, 99]
	Consumer acceptance	
AI	Consumer acceptance	Huang & Yang [92]

structure for interaction and consumer acceptance contribute to the role and acceptance of MR applications in sports. In AI, consumer acceptance analyses approach for AI adoption by customers.

Device innovation

The cluster device innovation focuses on innovations in devices, such as wearable technology, that transform how athletes train, how tourists experience destinations, and how events are managed and promoted. These studies identify the latest trends and their potential applications, emphasizing the importance of enhancing audience engagement. Table 3 demonstrates that this is dominantly present in IoT (four sub-themes), followed by VR (three sub-themes), XR (two sub-themes), AR, MR and AI (one sub-theme each).

Thematic analysis revealed that device innovation in VR encompasses three sub-themes: technological device/sensors advancements (e.g., Kurtzman & Zauhar [8]; Cardoso & Almeida [59]; Tu & Hwang [78]), integrating VR devices into leisure sports exercise [73], and attitudes toward new technologies and device sensors during activity [66]. These sub-themes focus on improving VR devices and exploring user attitudes toward new technologies.

In IoT, overlapping sub-themes with VR include technological device/sensors advancements and attitudes toward new technologies and device sensors during activity. Technological device/sensors advancements is a dominant sub-theme, with contributions from Muniz-Pardos et al. [49], Ágnes et al. [58], Perez-Aranda et al. [80], Achilleos et al. [82], Zeng et al. [84], Huang et al. [85], and Cairns [96]. Other IoT sub-themes are user-friendliness of devices [84] and health monitoring and exercise [4, 49], which examine how consumers use new technology and the impact of these devices on health issues.

Further analysis showed that technological device/sensors advancements (e.g., Langaro et al. [90]; Huang & Yang [92]) is also evident in AR, MR, and AI. It refers to the innovation of devices for trainings like virtual golf [66], virtual marathon race [75], digital running devices [84], GPS systems [85] or virtual soccer stage [94]. In XR, the additional sub-theme human-computer interaction design principles [91] outline principles that are intuitive, accessible, and user-friendly, ensuring a seamless and efficient user experience across different applications.

The cluster device innovation highlights the transformative potential of new devices in sports training, tourism, and event management. This comprehensive analysis underscores the significant role of device innovation in improving user engagement and operational efficiency. As technology continues

Table 3. Device innovation papers categorization to key sub-themes and new technology types

Technology type	Sub-theme	Source
VR	Technological device/sensors advancements	Kurtzman & Zauhar [8]; Cardoso & Almeida [59]; Tu & Hwang [78]
	Integrating VR devices into leisure sport exercise	Cheeyong et al. [73]
	Attitudes toward new technologies and device sensors during activity	Cardoso & Almeida [59]; Han et al. [66]
IoT	Technological device/sensors advancements	Muniz-Pardos et al. [49]; Agnes et al. [58]; Perez-Aranda et al. [80]; Achilleos et al. [82]; Zeng et al. [84]; Huang et al. [85]; Cairns [96]
	User-friendliness of devices	Zeng et al. [84]
	Attitudes toward new technologies and device sensors during activity	Huang et al. [85]
	Health monitoring and exercise	Fu [4]; Muniz-Pardos et al. [49]
AR	Technological device/sensors advancements	Uhrich et al. [61]; Glebova et al. [65]; Lei & Ngan [88]
XR	Infrastructure for interaction	Langaro et al. [90]; Liu et al. [91]
	Human-computer interaction design principles	Liu et al. [91]
MR	Technological device/sensors advancements	Westmattelmann et al. [6]
AI	Technological device/sensors advancements	Huang & Yang [92]

to evolve, its application in marketing and management within sport tourism is expected to advance, creating new markets, management practices, and competitive strategies [100].

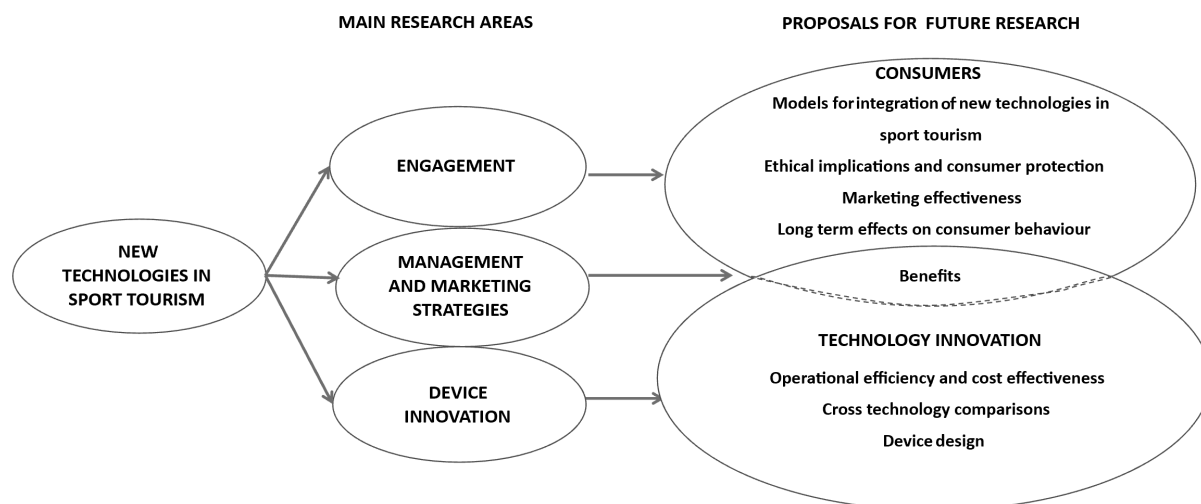
As the sport tourism industry continues to evolve through the integration of new technologies, as evidenced by the increasing number of papers published in the last five years, it becomes increasingly important to identify gaps in the current literature and suggest directions for future research that can guide the development of more effective policies, innovations and practices.

Directions and propositions for future research

Although the analysis of existing literature identifies three primary clusters where new technologies intersect with sport tourism, several important topics remain underexplored, prompting suggestions for further research directions (Fig. 5).

Based on the comprehensive literature review and identified gaps, future research in sport tourism should focus on two

main areas, namely consumers and technology innovations. Future research in sport tourism should prioritize a comprehensive exploration of consumer behavior, particularly focusing on how new technologies can be effectively integrated to meet evolving consumer needs. Developing robust models for integrating these innovations into sport tourism is essential, similar to the widespread application of the Technology Acceptance Model in the hotel industry (e.g., Li et al. [101]) and in studies on employee technology acceptance (e.g., Sun et al. [102]). Pashaie and Perić [74] also advocate for future research to focus on models that address the well-being, health, and safety of both tourists and employees in sport tourism, especially in the context of new technologies. Understanding consumer behavior in relation to new technologies is critical for effective marketing, as highlighting the benefits of these innovations is vital for attracting and retaining customers. This requires examining the long-term impacts of new technologies on consumer behavior, addressing ethical considerations, and ensuring consumer protection.

**Fig. 5.** Future research directions

Additionally, this line of research could inform the development of safety protocols in sport tourism, aligning with the findings of Agnes et al. [58]. Further, it is crucial to explore how different demographic groups, such as various age groups and genders, respond to new technologies, an importance highlighted in the work of Cardoso and de Almeida [59]. Developing tailored strategies for these specific consumer segments can significantly enhance engagement and satisfaction. Future research should also assess how new technologies can be effectively integrated into marketing activities within sport tourism to attract new audiences and boost engagement. In this context, Petit et al. [62] underscore the importance of marketing by analyzing the impact of new technologies on sponsor brands. Despite the frequent focus on consumers in the literature, there is a notable lack of longitudinal studies in this area, as also noted by Thompson et al. [76]. Expanding research in these directions will ensure that the sport tourism industry remains innovative, competitive, and responsive to the diverse needs of its consumers.

Exploring sport tourism's new technology benefits is vital and crosses both research directions. These benefits must be shown to consumers for marketing success and to ensure that innovations meet user needs. These user benefits, such as enhanced performance and convenience, make technology breakthroughs more likely to be embraced and advance. These benefits should be examined for operational efficiency and cost-effectiveness. Sport tourism lacks research on these elements, unlike the hotel industry and tourism business models [47]. Addressing this gap is crucial for industrial adoption and integration of breakthrough technology. Future studies can help sport tourism thrive in a tech-driven environment by concentrating on these overlapping benefits.

Conclusion

Theoretical implications

This study contributes to the theoretical framework by categorizing new technologies and demonstrating their applications within sport tourism. It extends theories on technology adoption and user engagement by showing how these technologies are becoming integral to the sport tourism industry. The comprehensive literature review highlights the transformative role of new technologies in revolutionizing sport tourism, significantly enhancing both participant and spectator experiences. This study identifies three key clusters where these technologies are making a profound impact. First, management and marketing strategies show an increasing reliance on innovative technologies to develop novel marketing approaches and drive strategic growth. Second, engagement emphasizes how immersive technologies are deepening the connection between participants, spectators, and the overall sporting experience. Third, device innovation showcases the ongoing advancements that are not only transforming how sports are played but also how they are viewed and managed. These clusters collectively illustrate the broad and deep influence of various technologies on the sport tourism landscape. In this sense, VR has been playing a particularly pivotal role in shaping consumer behavior and engagement over the past five years. The IoT has further enriched the experiences of both participants and spectators, while AR, MR, and XR, though less extensively explored, are beginning to enhance engagement by integrating virtual elements into real-world settings. Meanwhile, AI is revolutionizing the personalization and efficiency of sports experiences through data-driven insights.

Practical recommendations

Practically, the findings suggest that service providers should leverage advanced technologies to create more engaging and immersive experiences. By focusing on user expectations and effectively integrating new technologies, they can attract and retain participants and spectators. The insights highlight the importance of creating seamless and interactive experiences that align with evolving consumer preferences, guiding the adoption and integration of technologies in development, marketing, engagement, and device innovation. Designers of new technologies should prioritize creating user-friendly devices that are both functional and easy to use. Important is the need to advance research in technology innovation within sport tourism. This involves investigating the operational use of new technologies to enhance smart experiences and improve operational processes. For instance, there is a call for research into the design of devices specifically tailored to enhance the sport tourism experience, focusing on user-friendliness and functionality. Studies should also focus on the economic implications of these technologies, as emphasized by researchers like Achilleos et al. [82], who stress the importance of assessing financial impacts and operational efficiency. The goal is to explore more efficient and cost-effective implementation strategies, ensuring that these technologies benefit both the industry and consumers. The gap in comparative studies examining the effectiveness of different technologies within sport tourism also needs attention. For example, Bec et al. [103], and Wei et al. [104], highlighted the need to explore VR and MR technologies in tourism destinations within the same study.

Limitations

However, this study acknowledges certain limitations, such as its reliance on English-language publications and a specific dataset, which may not encompass all relevant research. Future research should broaden its scope to include a wider range of data sources and employ longitudinal studies to better capture the evolving nature of these themes. Additionally, assessing the practical efficacy of these technologies in real-world settings and understanding tourists' receptiveness and acceptance are crucial for successful implementation. These propositions aim to address current shortcomings, ensuring that future innovations foster more immersive, competitive, and fulfilling experiences, as frequently emphasized in the literature on participant experience. Addressing these gaps will provide a more comprehensive understanding of how different groups respond to new technologies, ensuring that future innovations are effectively tailored to meet diverse consumer needs and preferences.

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