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Unlocking Athletic Excellence: Role of Cutting-Edge Sport Technologies on Athletic Sports Development

Rasool Norouzi Seyed Hossini [1] | **Javad Fasanghari** [2] | **Maryam Amini** [3]

1. Corresponding author, Department of Sports Science, Faculty of Humanities, Tarbiat Modares University, Tehran, Iran. rasool.norouzi@modares.ac.ir
2. Department of Sports Science, Faculty of Humanities, Tarbiat Modares University, Tehran, Iran. h.farahani@modares.ac.ir
3. Department of Sport Management, Faculty of Physical Education and Sport Sciences, Shahid Chamran University, Ahvaz, Iran. Email: amini71.maryam@gmail.com

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ABSTRACT

The present research aimed to explore the role of modern sports technologies in the advancement of athletic sports, employing a mixed-method design. The qualitative phase utilized purposeful and criterion-oriented sampling methods, along with semi-structured interviews, while data collection and analysis were conducted using the thematic analysis method (Brown and Clark, 2006). In the quantitative phase, a questionnaire was developed, incorporating the dimensions and components identified in the qualitative phase. A random sampling method was employed, and Cochran's formula was utilized to determine the sample size for an unlimited statistical population, resulting in a determination of at least 384 samples. Ultimately, 356 questionnaires were collected. Descriptive statistics and Friedman's ranking test were employed for the quantitative data analysis. The findings revealed that the development of athletic sports through modern technologies comprises five main components: (1) factors influencing the development of athletic sports through technology, (2) the progression of athletic sports, (3) the challenges encountered in the development of athletic sports through technology, (4) the opportunities for enhancing athletic sports through technology, and (5) the consequences arising from the development of athletic sports through technology.

Introduction

Over the last five decades, our world has undergone profound structural changes on a global scale. These transformations encompass two major shifts. Firstly, there has been a notable increase in the production volume of goods and the provision of diverse services. Secondly, there has been a heightened emphasis on the efficient utilization of time, particularly in the context of sports activities (Cruz & Raurich, 2020). In this new era, human life, including sports, has been profoundly influenced by technological advancements (Wu, 2011). Notably, the sports industry has witnessed the integration of various emerging technologies in recent years (Kos et al., 2018). The COVID-19 pandemic acted as a catalyst, prompting numerous industries, including sports, to

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swiftly adopt digital technologies (Baig et al., 2020; González-Serrano et al., 2023). Amidst the pandemic, the sports sector embraced the use of novel sports technologies as well (González-Serrano et al., 2023). While the pandemic brought digital and sports technologies into sharper focus as part of a strategic response to global developments, sports brands have long been exploring the potential of these technologies to enhance consumer satisfaction and capture attention (Kim & Ko, 2019). These innovative technologies present ample opportunities for sports organizations, various sports federations, and their partners to elevate consumer and sports fan experiences (Hossini et al., 2014; Liu et al., 2023; Liu & Wang, 2023). In the realm of sports, innovation aims to generate fresh ideas and knowledge related to products, processes, services, or technologies that can effectively attract and retain sports consumers, thereby establishing a competitive advantage within the industry (González-Serrano et al., 2023; Hossini et al., 2014; Sandvoss, 2004). Essentially, today's intensely competitive landscape, shaped by digitalization, owes much to the profound impact of advanced technologies on the sports domain (Yuksel et al., 2021).

Athletic sports hold significant social and scientific value as specialized systems (Park et al., 2013; Wu, 2011). Their close association with a country's culture, politics, and economy makes it imperative for nations to establish a robust scientific, organizational, and infrastructural framework to display their standing on the international stage (Amini et al., 2020; de Koning, 2010). In the contemporary era, athletic sports have evolved into a complex and multidimensional phenomenon, demanding comprehensive attention to all aspects (Dellaserra et al., 2014; Wu, 2011). To grasp the intricacies and challenges of a country's athletic sports, a scientific and experimental approach is essential. Leveraging global experiences can prove to be a valuable shortcut to achieving development (Böhlke & Robinson, 2009). The researchers showed that the integration of new technologies has had positive impacts on the development of athletic sports worldwide. In today's world, several cutting-edge technologies have influenced sports significantly (Chen & Zhu, 2022; Seong & Hong, 2022; Wang & Jia, 2020). These technologies encompass virtual reality, the Internet of Things, wearable devices, applications, active video games, inflatable games, wind tunnels, holograms, touch technologies, video walls, and advanced sports equipment, among others (Chamorro-Koc et al., 2021). This technological competition has sparked greater innovation in sports and, consequently, emphasizes the need for sports managers with innovative approaches (Frevel et al., 2022; Liebermann et al., 2002; Ratten, 2020). Traditionally, sporting success relied on natural talent, rigorous training, and strategic acumen (Wu, 2011). While these factors remain crucial, the integration of innovative technologies has introduced groundbreaking opportunities to optimize athletic performance and training routines (Dellaserra et al., 2014; Park et al., 2013). Real-time data access empowers athletes and coaches to make data-driven decisions that can determine victory or defeat (Magdalinski, 2009).

As sports technologies continue to advance, they revolutionize the way championships are won and lost. Moreover, the impact of new sports technologies extends beyond athletic performance (Liu & Wang, 2023). Fan engagement and spectator experiences have been profoundly enhanced through virtual reality (VR), augmented reality (AR), and immersive viewing experiences (Kim & Ko, 2019). These technologies bridge the gap between fans and sports events, transcending geographical barriers and providing unprecedented access to the excitement of sports action (Mascret et al., 2022; Putranto et al., 2023). In recent years, the convergence of new technologies and sports has become a focal point for researchers. This review encompasses a selection of studies investigating the application and impact of various technological innovations in competitive and athletic sports. Wang (2012) explored the "Application of virtual reality in competitive and athletic sports," revealing its potential to create virtual training conditions, generate virtual opponents, collect physiological and biochemical indicators, and evaluate training and game outcomes. The study strongly supported the use of virtual reality in enhancing competitive sports, offering athletes novel challenges for improvement (Wang, 2012). Ringuet-Riot et al. (2014) focused on "Innovative planning for sports teams according to their need for innovation," highlighting the value of technology in facilitating communication and information dissemination about elite athletes for

coaches. While the benefits were evident at the elite level, the researchers emphasized the importance of further research on technological innovations in public and athletic sports, advocating for increased collaboration between sports organizations and technology institutions Ringuet-Riot et al. (2014). Fan (2017) examined "Innovation and Information Technology in the Development of Sports Science in China," identifying a growing interest in sports among the general population due to increased innovation. Innovation was found to not only enhance the appeal of sports but also enrich physical education exercises. Kim and Ko (2019) explored "The impact of virtual reality technologies on the experience and satisfaction of sports consumers," revealing that virtual reality significantly enhances user experiences, particularly among individuals less involved in sports, presenting an opportunity to attract new audiences (Kim & Ko, 2019). Soltani and Morice (2020) investigated "Augmented reality tools for training and sports training," concluding that this technology holds the potential to improve learning and providing valuable feedback to athletes. It was also found to bridge the gap between athletes and spectators, enhancing audience engagement. Plattfaut and Koch (2021) conducted a study on "Why professional football clubs use innovative technology processes," identifying key drivers behind the adoption of innovative technologies in professional sports, such as perceived efficiency, ease of use, and alignment with market demands (Plattfaut & Koch, 2021). Zhu and Kou (2021) focused on "3D simulation of swimming training based on Android mobile system and virtual reality technology," concluding that virtual reality technology significantly enhances swimming training, aiding in stretching movements, wall returns, and injury prevention during training.

Pizzo et al. (2022) investigated "Strategic advantage of the company has reached the stage of maturity: digitization and diversification of professional sports using electronic sports." The researchers proposed employing strategic management perspectives based on resource-based and knowledge-based approaches to gain competitive advantages in the digital era of professional sports (Pizzo et al., 2022). Frevel et al. (2022) conducted a prospective study titled "The Impact of Technology on Sports," emphasizing the transformative effects of rapid technological advancement and digitization on sports. They anticipated that technology would continue to reshape the sports landscape, influencing consumer experiences, creating new records, and fostering desirable skill sets for managers (Frevel et al., 2022). Mascret et al. (2022) found in their research that athletes across all levels expressed a strong desire to accept and embrace virtual reality technology (Mascret et al., 2022). Collectively, these studies shed light on the dynamic relationship between new technologies and sports, highlighting their immense potential to revolutionize various aspects of sports performance, training, spectator experiences, and management. As technology continues to evolve, its intersection with sports will play an increasingly pivotal role in shaping the future of sports engagement and competition. The development of athletic sports is influenced by various factors, including advancements in new technologies (Putranto et al., 2023). To effectively harness these technologies for the progress of athletic sports, several key considerations and actions need to be taken (Park et al., 2013; Wang, 2012). First, it is crucial to conduct studies and research on sports technologies implemented in advanced countries to model and adapt them to local contexts. This process can facilitate the integration of cutting-edge technologies into the sporting landscape. Secondly, cultivating experts in sports technologies and employing them with the support of government departments is essential. Establishing collaboration between government institutions responsible for community athletic sports can help understand society's potential and needs in this domain. Additionally, focusing on marketing aspects from economic, cultural, geographical, and demographic perspectives can build trust and encourage the adoption of champion technologies (Amini et al., 2020; Luczak et al., 2020). The term "development of athletic sports" in this research refers to creating influential and exemplary sports conditions within Iran by using sports technologies. The aim is to foster new forms of physical and sports activities that can be expanded and developed in the future. By incorporating sports technologies, it is anticipated that participation in athletic sports among different segments of society will increase. This research endeavors to

recognize the challenges and opportunities associated with developing athletic sports through new technologies. It seeks to provide comprehensive and scientific solutions to better manage this process, leading to substantial benefits and advancements in athletic sports through technology adoption. The findings of this research can offer valuable insights into the transformation our country experiences before and after the implementation of these technologies in athletic sports. Consequently, the fundamental question raised by this research is: What role do new sports technologies play in driving the development of athletic sports?

Methodology

The current research was conducted using a mixed-method design, combining both qualitative and quantitative approaches. The research plan followed an exploratory path, where the qualitative part was conducted first, followed by the quantitative part. Finally, an overarching interpretation was made by integrating the results from both components (Amiri & Norouzi Seyed Hossini, 2013). For the qualitative part, data were gathered through purposeful and criteria-based sampling, targeting academically educated specialists in physical education, sports science, technology, and sports engineering, as well as Iranian national-level athletics coaches. Semi-structured interviews were conducted with 25 participants to allow for in-depth exploration of their perspectives. Data saturation was achieved, ensuring a comprehensive collection of relevant insights. The interviews, each lasting approximately 60 to 90 minutes, were conducted over a period of six months, from January to June 2023. The lead author, who has expertise in sports technologies, conducted all interviews to leverage their insider perspective while ensuring empathy and authenticity in the data collection process. To minimize potential bias, the lead author maintained a professional distance and adhered to a structured interview protocol. Thematic analysis was employed to analyze the qualitative data. Following Braun and Clarke's (2006) six-phase method, the process included: familiarization with data, generating initial codes, identifying themes, reviewing themes, defining and naming themes, and presenting results. Transcripts were read repeatedly to immerse in the data, and an initial coding framework was developed. Data were then organized into themes based on the coding framework, reviewed, refined, and accurately defined to reflect the data. Final themes were presented in the study. To ensure reliability and validity, the research team regularly reviewed and compared codes and themes. Member checking was employed by sharing transcripts, codes, and themes with participants for verification. Pseudonyms (e.g., no1, no2) were used to maintain participant anonymity in the final report. To supplement the qualitative findings, a targeted review of documents and library studies was conducted. This involved examining articles, books, reports, portals, and databases containing models of using technology in sports development. The data collection process continued until saturation was achieved, ensuring comprehensive coverage of relevant literature (Clarke & Braun, 2018).

By employing a mixed-method design, the research aimed to provide a comprehensive understanding of the role of technology in advancing athletic sports. The qualitative interviews allowed for nuanced insights from experts, while the document review enriched the study with a broader context of existing models and practices in technology-based sports development. The integration of both qualitative and quantitative data enabled the researchers to offer a well-rounded interpretation of the results, contributing to a more comprehensive understanding of the subject matter (Clarke & Braun, 2018). The sample size for the qualitative part was justified based on the principle of data saturation, which was achieved with 25 participants. Saturation was determined when additional interviews no longer provided new themes or insights. This approach ensures the reliability and validity of the qualitative findings by confirming that the sample size was sufficient to capture the full range of perspectives relevant to the research questions. To enhance the credibility of the qualitative research, several strategies were employed: the lead author's familiarity with the specialized population facilitated authentic and detailed accounts, member checking was utilized by having participants review their transcripts, codes, and themes to ensure accurate

representation, pseudonyms were used to protect participant identities, and regular team reviews were conducted to compare, review, and refine emergent themes, addressing any discrepancies collaboratively. By meticulously following these procedures, the study ensured the reliability and validity of the qualitative data, contributing to the robustness of the overall research findings.

The quantitative part of this study targeted the entire staff, managers, officials, and employees involved in athletic sports. Due to the extensive and diverse nature of the population, a random sampling method was adopted. Given the lack of precise information about the total population, Cochran's sample size formula for an unlimited statistical population was employed, resulting in a sample size of 384 individuals for the quantitative phase. To gather data, a questionnaire was developed based on the components identified during the qualitative interviews. This questionnaire was distributed both online and physically among the research sample, which consisted of specialists with academic education in physical education and sports science (covering all trends), technology (in various disciplines), sports engineering, and athletics coaches. Questionnaires were distributed from June 2023 and the process of distributing questionnaires continued for 4 months. The questionnaires were distributed using two primary methods: online and physical. Online distribution was facilitated through two platforms: Porsline (https://porsline.ir/) and Google Forms. These platforms were chosen for their user-friendly interfaces, wide reach, and ability to easily collect and organize responses. Links to the online questionnaire were sent via email and social media platforms to the target participants, ensuring broad accessibility and convenience for respondents. Physical distribution involved handing out printed questionnaires at various sports and academic events, conferences, and workshops related to physical education, sports science, and technology. This approach aimed to capture responses from individuals who might prefer or have better access to paper-based surveys.

To ensure a coordinated approach, both online and physical distributions were carefully monitored and managed. Each questionnaire, whether distributed online or in person, contained identical questions to maintain consistency in data collection. Follow-up reminders were sent via email and in-person during subsequent events to encourage participation and timely responses. The response rates and participant characteristics were tracked and analyzed to identify any differences between the two modes of distribution. The online distribution yielded a higher response rate compared to the physical distribution, likely due to the convenience and accessibility of completing the questionnaire digitally. Participants who responded online tended to be younger and more familiar with digital technologies, while those who completed the physical questionnaires were often older and more comfortable with traditional methods. Despite these differences, the overall response quality and the diversity of participant backgrounds were maintained across both distribution methods. This dual approach ensured a comprehensive representation of the target sample, enhancing the reliability and validity of the research findings.

In our study, a total of 384 questionnaires were initially distributed. Out of these, 18 were deemed unreliable and subsequently discarded. These 18 questionnaires were identified based on specific criteria: incomplete responses that compromised data integrity, inconsistent answers, and patterned responses indicating a lack of genuine engagement. Additionally, 10 more questionnaires were discarded due to being incomplete or invalid, which included missing key responses or containing contradictory information. Consequently, 356 completed questionnaires were subjected to analysis, resulting in a high response rate of 92.70%. The table 1 provides a detailed description of the participants in both the qualitative and quantitative parts of the research. The questionnaire designed for this study aims to assess the impact of new technologies on the development of athletic sports. The face and content validity of the questionnaire were meticulously evaluated through expert input. Twelve experts in the field were consulted to assess the questionnaire's relevance, clarity, and appropriateness in measuring the intended constructs. The experts provided valuable feedback and recommendations, which were thoroughly considered and integrated into the questionnaire to enhance its content and face validity. The modifications based on the experts'

suggestions affirmed the validity of the instrument. To ensure the reliability of the questionnaire, a pilot test was conducted among 30 participants from the target population. Cronbach's alpha, a widely recognized measure of internal consistency, was calculated to assess the reliability of the questionnaire. Cronbach's alpha for the tool was found to be 0.821, indicating a high level of internal consistency and, consequently, affirming the good reliability of the questionnaire. This value suggests that the items within the questionnaire are consistently measuring the intended constructs, underscoring the robustness of the instrument. In conclusion, the questionnaire designed to investigate the role of new technologies in the development of athletic sports underwent rigorous assessment of validity and reliability. The input from experts ensured the questionnaire's appropriateness and clarity, while the high Cronbach's alpha value demonstrated the internal consistency and reliability of the instrument, providing confidence in its effectiveness for data collection in this study.

Table 1. Characteristics of qualitative part participants and quantitative part samples

Phase	N(total)	Features and specifications	N
Qualitative	25	Academic professors and researchers (sports management, sports technologies, sports development, etc.)	12
		Managers and experts of sports organizations	5
		Sports technology experts	3
		Managers and experts of institutions and companies providing sports technologies	5
Quantitative	384 (356 final samples with a return rate of 92.70 percent)	Informed managers and experts in sports and youth departments	37
		Informed managers and experts in sports teams	46
		Researchers and experts in the field of sports technologies	73
		Managers and experts of athletic sports	42
		Informed managers and experts in the municipal sports organization	35
		Professors, students, and sports technology research specialists	356

In the quantitative phase of this study, the components identified through qualitative analysis were utilized to collect and align quantitative data. To achieve this, a questionnaire was developed, encompassing the dimensions and components outlined in the model based on the findings from the qualitative section. Descriptive statistics, such as mean, standard deviation, and frequency percentage, were employed to describe the demographic characteristics of the participants and to present their views on the research variables. To prioritize the components and their dimensions, the researchers employed the Friedman ranking test. This statistical test allows for the comparison and ranking of multiple variables based on their average ranks. The collected data were analyzed using the SPSS/25 software, a commonly used tool for statistical analysis, facilitating the processing and interpretation of the data obtained from the respondents. By utilizing this software, the researchers were able to gain valuable insights and draw meaningful conclusions from the quantitative data collected in the study.

Results

Table 2 provides an example of the general method of initial coding, illustrating how the data from interviews are organized and categorized to facilitate the subsequent analysis and interpretation process. By employing this systematic approach to coding, the qualitative part of the research aims to extract meaningful insights from the interview data and identify recurring themes that contribute to a comprehensive understanding of the phenomenon under study. This process helps researchers formulate more abstract and valuable interpretations based on the lived experiences and perspectives of the research participants.

Table 2. Some examples of the initial coding of interviews with research participants

	Examples of corresponding expressions and important statements	Initial codes	Frequency
1	*It seems that the application of new technologies in athletic sports is not taken seriously (IN.No.1); Many disciplines use the same traditional procedures to prepare athletes (IN.No.5); Coaches and sports champions are unaware of technologies and are not familiar with them to a large extent (IN.No.2).*	Not taking new technologies seriously/ the traditional mechanism established in sports fields/ neglecting the use of technologies in sports	7
2	*Athletes and champions can improve their performance by using technologies (IN.No.10). From the point of view of business, new technologies can facilitate the commercialization of sports (IN.No.15). To make better use of new technologies in athletic sports, needs should be assessed (IN.No.12).*	Improving the performance of sports champions/ the presence of favorable platforms for the use of technology/ needs assessment of the use of sports technologies	3
3	*Coaches and athletes should receive the necessary training regarding the use of new technologies (IN.No.11). The more the practitioners of the sport are familiar with technology, the more likely it is that technologies can be used in sports faster (IN.No.2). Training is the introduction to the correct use of any technology, especially sports technologies (IN.No.21).*	The necessity of technology education/precedence of education to use in new technologies	5
4	*New technologies can improve athletes and sports teams (IN.No.18). in many sports boards, there is no desire to use new technologies and invest in this field (IN.No.15). Some sports managers and policymakers have a negative view of new technologies (IN.No.10).*	Countless benefits of technologies in the development of sports/ reluctance to new technologies/ existence of a negative view towards technologies	9
5	*Through the application of new technologies in athletic sports, we will move towards the internationalization of sports (IN.No.20). In the application of new technologies in the development of athletic sports, special requirements should be considered (IN.No.11).*	Moving towards the internationalization of sports/ meeting the specific requirements of the use of new sports technologies	4
6	*The use of new technologies in athletic sports improves the status and reputation of some sports boards (IN.No.18). The possibility of the effectiveness of some institutions that use new sports technologies will be greater in the management of community sports (IN.No.8).*	Enhancing the status and reputation of sports boards/ the possibility of more influence in sports management	9
7	*The application of new technologies in athletic sports should make a difference at the level of coaches, clubs, and athletes (IN.No.1).*	Improving the status of clubs, coaches, and athletes	4

After coding, the data were analyzed by sorting and grouping similar codes into distinct categories. This iterative process ensured accuracy and consistency through repeated comparisons. Categories were named based on a thorough review of interview texts and documents, capturing their essence meaningfully. Ultimately, 25 categories emerged, organized into five main themes, highlighting the impact of new technologies on athletic sports. A summary is provided in Table 3.

Table 3. Categories and themes of the role of new technologies in the development of athletic sports

	Categories	Themes
1	Internationalization of technology-oriented athletic sports	Factors affecting the development of athletic sports through technology
2	Alignment with sports trends and competitions	
3	The need to improve sports skills through technology	
4	Expanding the smartness of athletic sports	
5	Development of technological competition in the field of sports	
6	winning-Medal and Promotion of athletic sports	Development of athletic sports through technology
7	A comprehensive and integrated approach to improving the performance of champions	
8	Systematic talent development in athletic sports	
9	Development of infrastructure in athletic sports	
10	Comprehensive support for champions	
11	Lack of technology-oriented policy in athletic sports	Challenges of Developing Athletic Sports through Technology
12	Interest conflict in medal-winning sports	
13	Conflict of interests of managers and directors of athletic sports	
14	Absence of technological platforms in athletic sports	
15	Dominating the traditional view on athletic sports	
16	Taking advantage of the international experiences of using technology in athletic sports	Opportunities of developing athletic sports through technology
17	Co-creation and synergy in medal-winning disciplines	
18	Marketing new technologies in athletic sports	
19	Commercialization of new technologies in athletic sports	
20	Multiple applications of new technologies in athletic sports	
21	Creating technology-based championship platforms	Consequences of the Development of Athletic Sports through Technology
22	Institutionalization of technology in athletic sports	
23	The multi-functionality of athletic sports	
24	Establishing a sports digital ecosystem	
25	Improving the competitive advantages of athletic sports	

In the quantitative section of the study, the demographic characteristics of the research samples are presented in the table below.

Table 4. Demographic characteristics of the samples of the quantitative part of the research

Variable	Division	N	Percent
Age	20-30	16	5.1
	31-40	104	28.9
	41-50	182	51.3
	51-60	48	12.8
	61years and older	6	1.7
Level of Education	Diploma and below	6	1.7
	Associate Degree	8	2.5
	B.A	168	46.5
	M.A	158	44.1
	Ph.D.	16	5.3
History of activity and experience in athletic sports	5 years and less	12	3.3
	6-10	30	8.2
	11-15	78	20.3
	16-20	52	15.3

	21 years and older	184	52.9
	Sum	356	100

The table below illustrates the significance of each variable and subscale in athletic sports. The ratings were obtained using a 7-point Likert scale, as perceived by 356 scientific and executive experts in the field of athletic sports. This scale allowed the respondents to provide their assessments based on their expertise and experience, offering valuable insights into the importance of each aspect within the realm of athletic sports.

Table 5. Descriptive statistics of athletic sports variables and subscales

	Themes	Categories	M	S.D	Total
1	Factors affecting the development of athletic sports through technology	Internationalization of technology-oriented athletic sports	4.079	0.221	4.311(±0.491)
2		Alignment with sports trends and competitions	3.968	0.901	
3		The need to improve sports skills through technology	5.063	0.113	
4		Expanding the smartness of athletic sports	4.079	0.981	
5		Development of technological competition in the field of sports	4.714	0.239	
6	Development of athletic sports through technology	winning-Medal and Promotion of athletic sports	5.206	0.211	4.797(±0.319)
7		A comprehensive and integrated approach to improving the performance of champions	4.429	0.290	
8		Systematic talent development in athletic sports	4.713	0.331	
9		Development of infrastructure in athletic sports	4.524	0.321	
10		Comprehensive support for champions	5.114	0.442	
11	Challenges of Developing Athletic Sports through Technology	Lack of technology-oriented policy in athletic sports	4.783	0.870	4.929(±0.538)
12		Interest conflict in medal-winning sports	4.516	0.651	
13		Conflict of interests of managers and directors of athletic sports	4.762	0.267	
14		Absence of technological platforms in athletic sports	5.556	0.655	
15		Dominating the traditional view on athletic sports	4.942	0.247	
16	Opportunities of developing athletic sports through technology	Taking advantage of the international experiences of using technology in athletic sports	4.829	0.800	4.698(±0.567)
17		Co-creation and synergy in medal-winning disciplines	5.254	0.234	
18		Marketing new technologies in athletic sports	4.235	0.341	
19		Commercialization of new technologies in athletic sports	3.968	0.861	
20		Multiple applications of new technologies in athletic sports	5.206	0.601	
21	Consequences of the Development of Athletic Sports through Technology	Creating technology-based championship platforms	4.852	0.245	4.827(±0.377)
22		Institutionalization of technology in athletic sports	4.254	0.452	
23		The multi-functionality of athletic sports	5.125	0.421	
24		Establishing a sports digital ecosystem	4.786	0.651	
25		Improving the competitive advantages of athletic sports	5.121	0.120	

Friedman's ranking test was used to prioritize factors influencing the development of athletic sports through new technologies (X^2=20.231, df=4, p<0.01). The factors were ranked as follows: (1) Internationalization of technology-oriented athletic sports, (2) Alignment with sports trends and competitions, (3) Expansion of smart athletic sports, (4) Need to enhance sports skills through technology, and (5) Growth of technological competition in sports. The statistical significance (p<0.01) underscores their critical role in advancing athletic sports. These findings provide valuable direction for decision-makers and stakeholders to focus on the most impactful areas.

Table 6. The results of Friedman's ranking test for prioritizing factors affecting the development of athletic sports through new technologies

	Component	Mean rank	Priority	X^2	DF	Sig
1	Internationalization of technology-oriented athletic sports	5.01	1	20.231	4	0.001
2	Alignment with sports trends and competitions	4.92	2			
3	The requirement to improve sports skills through technology	3.41	4			
4	Expanding the smartness of athletic sports	4.75	3			
5	Expansion of technological competition in the field of sports	2.12	5			

Friedman's ranking test was used to prioritize the components of athletic sports development (X^2=29.112, df=4, p<0.01). The rankings were as follows: (1) Medal-winning and promotion of sports status, (2) Comprehensive support for champions, (3) An integrated approach to enhancing champions' performance, (4) Systematic talent development, and (5) Development of athletic sports infrastructure. The statistical significance (p<0.01) highlights their crucial role in advancing athletic sports. These insights guide policymakers, sports organizations, and stakeholders in focusing on the most impactful areas to enhance performance, recognition, and overall development.

Table 7. The results of Friedman's ranking test for the components of athletic sports development

	Component	Mean rank	Priority	X^2	DF	Sig
1	winning-Medal and promotion of sports status	4.85	1	29.112	4	0.001
2	A comprehensive and integrated approach to improving the performance of champions	4.01	3			
3	Systematic talent development	3.50	4			
4	Development of athletic sports infrastructure	2.48	5			
5	Comprehensive support for champions	4.61	2			

Friedman's ranking test was used to prioritize the development challenges of athletic sports through new technologies. As can be seen in the table below, based on the results of Friedman's ranking test (X^2=19.921, df=4, p<0.01), among the dimensions of the challenges of developing athletic sports through modern technologies, in the order of Dominating the traditional view of the mechanism of athletic sports, Absence of technological platforms in athletic sports, Entanglement of interest in medal-winning sports, Conflict of interests of managers and directors of athletic sports, and finally, Lack of technology-oriented Policy in athletic sports are the first to fifth priorities (P<0.01).

Table 8. The results of Friedman's ranking test for prioritizing the challenges of developing athletic sports through new technologies

	Component	Mean rank	Priority	X^2	DF	Sig
1	Lack of technology-oriented Policy in athletic sports	3.01	5	19.921	4	0.001
2	Entanglement of interest in medal-winning sports	4.90	3			
3	Conflict of interests of managers and directors of athletic sports	4.21	4			
4	Absence of technological platforms in athletic sports	5.72	2			
5	Dominating the traditional view of the mechanism of athletic sports	6.11	1			

Friedman's ranking test was used to prioritize the development opportunities of athletic sports through new technologies. As can be seen in the table below, based on the results of Friedman's ranking test (X^2=23.651, d.f=4, p<0.01), among the opportunities to develop athletic sports through new technologies, in the order of Co-creation and synergy in medal-winning disciplines, Various applications of new technologies in athletic sports, Taking advantage of the international experiences of using technology in athletic sports, Commercialization of new technologies of athletic sports, and finally, Marketing new technologies of athletic sports are the first to fifth priorities (P<0.01).

Table 9. The results of Friedman's ranking test for prioritizing opportunities for the development of athletic sports through new technologies

	Component	Mean rank	Priority	X^2	DF	Sig
1	Taking advantage of the international experiences of using technology in athletic sports	4.87	3	23.651	4	0.001
2	Co-creation and synergy in medal-winning disciplines	5.91	1			
3	Marketing new technologies in athletic sports	3.21	5			
4	Commercialization of new technologies in athletic sports	4.10	4			
5	Various applications of new technologies in athletic sports	5.30	2			

Friedman's ranking test was used to prioritize the consequences of the development of athletic sports through new technologies. As can be seen in the table below, based on the results of Friedman's ranking test (X^2=16.894, df=4, p<0.01), among the consequences of the development of athletic sports through new technologies, in the order of Improving the competitive advantages of athletic sports, The multi-functionality of sports Creating technology-based hero platforms, Establishing a sports digital ecosystem, and finally, Institutionalization of technology in athletic sports are the first to fifth priorities (P<0.01).

Table 10. The results of Friedman's ranking test for prioritizing the consequences of the development of athletic sports through new technologies

	Component	Mean rank	Priority	X^2	DF	Sig
1	Creating technology-based hero platforms	4.82	3	16.894	4	0.001
2	Institutionalization of technology in athletic sports	5.01	5			
3	The multi-functionality of sports	5.55	2			
4	Establishing a sports digital ecosystem	4.78	4			
5	Improving the competitive advantages of athletic sports	6.10	1			

Discussion and Conclusion

The primary objective of this research was to investigate the role of new sports technologies in the advancement of Athletic Sports. To achieve this goal, the research focused on examining key themes and analyzing and prioritizing quantitative data. The findings revealed that factors influencing the development of athletic sports through new technologies can be categorized into five sub-themes: Internationalization of technology-oriented athletic sports, alignment with sports trends and competitions, expansion of smartness in athletic sports, the need to enhance sports skills through technology, and the growing technological competition in sports. This research cites the works of Frevel et al. (2022); Kim and Ko (2019); Ringuet-Riot et al. (2014), and Plattfaut and Koch (2021) as relevant references. In terms of the factors impacting the development of athletic sports through new technologies, it is crucial to consider and address various significant aspects related to the athletic sports sector. This includes the involvement of championship athletes, coaches, television viewers, media, spectators, sponsors, and advertisers. By focusing on these diverse stakeholders, we can better understand the comprehensive implications of integrating new technologies into the athletic sports sector. In today's competitive world, athletes require detailed information to excel in various sports fields and achieve success in championships (Park et al., 2013; Wu, 2011). This includes information related to training preparation, physical and mental characteristics, records, nutritional status, deficiencies, and assessing their training needs. As highlighted by Ringuet-Riot et al. (2014), utilizing existing sports technologies specific to each sports field can significantly enhance sports skills. Championship athletes must embrace these technologies to align themselves with sports trends and competitions, just as their counterparts in other advanced countries are already doing in the athletic sports arena (Liu et al., 2023). Such alignment and technological awareness among athletes can serve as valuable feedback for their progress (Liu & Wang, 2023). Overall, this research sheds light on the potential of new sports technologies in elevating championship sports and emphasizes the importance of strategic adoption and integration of these innovations to improve athletes' performance and competitiveness on the global stage.

Today, the expansion of technological competitions in athletic sports has become imperative for championship athletes to embrace smarter athletic practices (Kim & Ko, 2019). The influence of new technologies on the factors affecting the development of athletic sports in the athletes' sector can be seen more clearly when other aspects related to championship athletes are also considered. One such crucial aspect is the role of coaches, who can leverage new sports technologies to provide modern, planned, scientific, and updated exercises for their athletes (Wu, 2011). By keeping pace with other coaches worldwide, they can contribute significantly to the advancement of athletic sports through new technologies (Pizzo et al., 2022; Putranto et al., 2023; Soltani & Morice, 2020). The research yielded insights into the challenges of developing athletic sports through technology, which can be categorized into five sub-themes: Dominating the traditional view of the mechanism of athletic sports, Absence of technological platforms in athletic sports, Entanglement of interest in medal-winning sports, Conflict of interests of managers and directors of athletic sports, and finally, Lack of technology-oriented Policy in athletic sports. The works of Kim and Ko (2019); Ringuet-Riot et al. (2014), and Plattfaut and Koch (2021) were referred to in this research(Kim & Ko, 2019; Plattfaut & Koch, 2021; Ringuet-Riot et al., 2014). Among the challenges, one of the most significant obstacles to adopting new technologies in the development of athletic sports is the dominance of the traditional view of the mechanism of athletic sports. Until the country's executive officials pay attention to the field of technology in athletic sports and conduct research in this area, the issue may be overlooked at lower levels, such as athletes and coaches themselves. This traditional view hinders athletes and coaches from accessing and utilizing these technologies for greater success and the advancement of athletic sports, putting them at a disadvantage compared to athletes from more technologically advanced countries. As Plattfaut and Koch (2021) highlighted,

the existence and prevalence of traditional thoughts hinder the creation of a technology-oriented platform in athletic sports. This absence of a platform for integrating new technologies leads to a lack of technology-oriented policies in the field, conflicts of interest among sports managers and administrators, and entanglement of interests in medal-winning sports and federations. Consequently, the presence of traditional views and the absence of technology-oriented policies negatively impact the overall development and progress of athletic sports. If higher-ranking policymakers in non-sports fields lack an understanding of the specialized conditions of sports and fail to recognize the importance of technology in athletic sports, it can lead to a lack of support for the development of championship sports. Consequently, the athletic sports sector may lag in its advancement and updating, and the potential for failure among most athletes increases (Park et al., 2013). For true progress, the country's main policymakers need to show genuine concern and support for the development and pursuit of championship sports. This support will create an environment conducive to adopting and implementing new technologies in athletic sports, thereby fostering a thriving and technologically advanced athletic landscape.

The opportunities for the development of athletic sports through new technologies are closely linked to the potential positive outcomes that can be achieved through their implementation. As mentioned by Plattfaut and Koch (2021), one significant opportunity lies in exploring various applications of new technologies in athletic sports. Integrating entertainment technologies, for example, can create a more engaging training environment for athletes, reducing boredom during rigorous preparation for championships (Chamorro-Koc et al., 2021; González-Serrano et al., 2023; Sandvoss, 2004). This enhanced training atmosphere can contribute to the success and mental preparedness of athletes, especially in the context of increased competitiveness among athletes worldwide. To align with international movements and advancements, sports federations, athletes, and coaches must actively research and understand technologies applicable to their respective fields of sports development. By introducing these technologies and building the necessary infrastructure, they can elevate the standard of championship sports to international levels (Liu et al., 2023; Wu, 2011). However, mere introduction alone is not sufficient. It is recommended that sports federations organize knowledge-enhancing courses for coaches and athletes to familiarize them with international developments. Such initiatives can motivate athletes and coaches, encouraging them to strive for success while receiving full support from the federation (Chen & Zhu, 2022). Implementing and testing these technologies at a smaller scale, such as in influential provinces, allows for better planning regarding their practicality and impact before broader implementation across the country (Wu, 2011). The consequences of the development of athletic sports through new technologies can be divided into three parts. Firstly, sports become more multifunctional, forming technology-based champion breeding platforms and enhancing competitive advantages in athletic sports. These outcomes contribute to the establishment of a sports digital ecosystem, ultimately leading to the institutionalization of technology in athletic sports (Plattfaut & Koch, 2021; Putranto et al., 2023; Ringuet-Riot et al., 2014).

Regarding the multi-use of athletic sports through new technologies, this concept encompasses all the factors discussed in the section related to the development of athletic sports. Emphasizing new technologies in athletic sports not only benefits the sports' progress but also extends their impact to other sectors related to athletic sports (Park et al., 2013; Wang & Jia, 2020). This integration can boost motivation among families and aspiring athletes when witnessing the successes of national athletes. Additionally, technology can play a crucial role in talent search and cultivation by leveraging accurate data and information on emerging talents' mental, and physical characteristics, and anatomy (Chamorro-Koc et al., 2021; González-Serrano et al., 2023). The success of athletic sports with the aid of up-to-date facilities can foster interest in sports among students with varying personality types in schools nationwide (Seong & Hong, 2022). In conclusion, the opportunities presented by new technologies in athletic sports offer a promising path

toward further development and success in the sports arena. Embracing technology, understanding its potential applications, and fostering a supportive ecosystem can elevate athletic sports to greater heights on both national and international levels.

In conclusion, the research findings unequivocally indicate that technology will emerge as a central and compelling focus in the realm of sports, particularly shortly. Anticipated structural changes will permeate all aspects of sports, with a particular emphasis on athletic sports activities. The present rise in human-computer technological interaction is already facilitating novel applications of technology in sports environments, transcending existing boundaries and revolutionizing physical development. Given the significance of these advancements, our entire nation must prioritize the development of public sports. Key sub-themes, including the internationalization of technology-oriented athletic sports, alignment with sports trends and competitions, the imperative of improving sports skills through technology, embracing the smartness of athletic sports, and fostering technological competition in the sports arena, must be given due attention. In addressing the challenges of athletic sports development through technology, it is essential to rectify issues such as the lack of technology-oriented policies, the entanglement of interests in medal-winning sports, conflicts among sports managers and administrators, the absence of technology-oriented platforms, and the predominance of traditional views in athletic sports. Seizing the development opportunities is equally important, encompassing the assimilation of international experiences in applying technology to athletic sports, fostering co-creation and synergy in medal-winning disciplines, marketing and commercialization of new athletic sports technologies, and exploring diverse applications of cutting-edge technologies. Additionally, focusing on awarding and promoting sports status, adopting a comprehensive approach to enhancing champions' performance, implementing talent search and systematic talent cultivation, investing in athletic sports infrastructure, and providing comprehensive support for champions are pivotal in creating a fertile ground for progress. Furthermore, establishing technology-based champion breeding platforms, institutionalizing technology in athletic sports, and embracing the multi-functionalization of sports contribute to the creation of a digital sports ecosystem, enhancing the competitive advantages of athletic sports. In light of these findings and their implications, it is imperative that we meticulously consider the five main themes: factors influencing the development of athletic sports through new technologies, the challenges posed by this development, the various opportunities it offers, the components integral to the progress, and the subsequent consequences. Only through such comprehensive consideration can we ensure that the advancement of athletic sports aligns harmoniously with global sports' progress, especially in the domain of world athletic sports. By embracing technology's immense potential and staying at the forefront of innovation, our sports sector can strive for excellence and make a lasting impact on the world stage.

Limitations and future research

The present research has limitations that should be acknowledged to contextualize its findings and guide future inquiries. This study focused exclusively on the role of new technologies in championship sports, thereby excluding other critical areas such as professional, training, and educational sports. This narrow scope limits the generalizability of the findings across the broader spectrum of sports activities and their various developmental stages. The present research did not delve into the impact of specific sports technologies through empirical methods. As a result, the study lacks detailed insights into how particular technologies influence championship sports. Future research could benefit from investigating individual technologies to provide more targeted and actionable insights. Furthermore, this study was not conducted in a comparative manner and did not explore the role of new technologies in championship sports across different countries. The absence of a comparative perspective limits the understanding of how cultural, economic, and infrastructural

differences might affect the adoption and impact of sports technologies in diverse international contexts.

To build on the foundation laid by this research, future studies should consider a broader range of sports categories, including professional, training, and educational sports, to provide a more comprehensive understanding of how new technologies influence various facets of sports development. Additionally, employing empirical research methods to investigate specific sports technologies would yield more granular data on their effectiveness and application in championship sports. Comparative studies across different countries would also be valuable. Such research could highlight best practices and contextual differences, providing a richer, more nuanced view of the global impact of sports technologies. By addressing these limitations, future research can offer deeper insights and more practical recommendations for integrating new technologies into the athletic sports sector globally.

Data availability statements

The datasets generated during and/or analyzed during the current study are not publicly available due to the obligations of authors to the General Directorate of Sports and Youth of Tehran Province for data protection but are available from the corresponding author upon reasonable request.

Ethical Considerations

All ethical principles are considered in this article. The participants were informed about the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information, and if desired, the research results would be available to them.

Competing interests

The authors declared no conflict of interest.

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