International Journal of Science, Technology and Society
2025, Vol. 13, No. 3, pp. 64-72
https://doi.org/10.11648/j.ajss.20251303.12

Review Article

Technological Innovations in Sports Science for Sustainable Sports Development in Nigeria

Joy Nneoma Akameze[1, *], Andrew Aor Tyoakaa[2], God'sman Chidiebube Akameze[3]

[1]Department of Sports and Exercise Medical Sciences, School of Sports and Exercise Medicine, University of Health and Allied Sciences, Ho, Ghana

[2]Department of Science and Technology, Vaatia College, Makurdi, Nigeria

[3]Department of Information Technology, Kaplan Business School, Melbourne, Australia

Abstract

Advances in science and Technology had led the world through many ages/eras. More importantly, the use of Technological innovations in the 21st century is a welcome development. Technology has taken all aspects in life and sport is not an exception. Lighter and stronger racquets, new material compounds and everlasting rubber soles, the possibility of having telemetry data available are just few of the developments that have set a remarkably highly competitive level among amateurs and professionals. Observation indicates that Nigeria sports industry is yet to utilize some of these advantages offered by technology to make sports performance and officiating easy and effective for her athletes. This paper stems from the quest to discover technological innovations needed to bring notably sustainable developments to global sports with focus on Nigeria. Therefore, Infrastructure development, the use of various technological devices for participation and officiating in some sports, future innovation in Sports Technology and Merits of Technological innovations were discussed in this paper. This paper therefore used Narrative Methodological Review approach, on the current trend in Technological innovations in sports science. Though, these are really effective but some are lacking in Nigeria. While global sports industries harness cutting-edge technologies to elevate performance, fan experience, and data analytics, Nigeria grapples with structural, socioeconomic, and policy-based obstacles. The paper also pointed out sporting activities that require the deployment of technological innovation to achieve sustainable development in the country. Reference was also made to other countries within and outside Africa on how the use of technological innovation has brought sustainable development in Sports. It was therefore concluded that should Nigeria employ most of these technological advancements in sports such as wearable technology, data analytics, and environmental sustainability measures, Nigeria can ensure the long-term viability and success of sports activities while minimizing their environmental impact and promoting sustainability in Sports.

Keywords

Technological Innovations, Sports Development, Wearable Technology, Sports Entrepreneurship

[*]Corresponding author: jakameze@uhas.edu.gh (Joy Nneoma Akameze)

Received: 6 June 2025; **Accepted:** 23 June 2025; **Published:** 21 July 2025

1. Introduction

The intersection of technology and sports science is profoundly reshaping the landscape of sports development, fostering both enhanced athletic performance and sustainability. As the global community intensifies its focus on sustainable practices, sports sectors are increasingly adopting technological innovations to address environmental and social responsibilities. These advancements are crucial for driving sustainable sports development, balancing the demands of high performance with the need for ecological stewardship. One significant area of technological advancement is the use of advanced data analytics and wearable technology. Devices such as fitness trackers and smartwatches provide real-time data on athletes' physical conditions, enabling precise monitoring and personalized training programs. This technology aids in injury prevention and performance optimization, thereby extending athletes' careers and reducing the necessity for resource-intensive training interventions [1].

The shift towards eco-friendly sports equipment and apparel marks a significant step towards sustainability. Innovations such as biodegradable materials, recycled fibers and energy-efficient manufacturing processes collectively reduce the environmental footprint of the sports industry [2]. This transition not only lessens adverse environmental impacts but also encourages responsible consumption and production, aligning with global sustainability goals. Smart stadiums represent another technological frontier contributing to sustainable sports development. These facilities incorporate renewable energy sources, waste reduction systems, and smart crowd management technologies to minimize their ecological impact. Features like solar panels, rainwater harvesting systems, and automated energy management systems are becoming integral to stadium designs, promoting more sustainable sports infrastructures [3].

Additionally, virtual and augmented reality (VR/AR) technologies are revolutionizing fan engagement by offering immersive experiences that reduce the need for travel, thereby cutting down travel-related emissions and the environmental impact of large-scale sports events [4]. These technologies allow sports organizations to engage a global audience while mitigating environmental costs associated with physical attendance. Artificial intelligence (AI) and machine learning (ML) are also pivotal in sports science, aiding in talent identification, performance analysis, and strategic planning, which enhances both efficiency and equity in sports [5]. AI-driven insights support informed decision-making, boosting performance while promoting fairness and inclusivity. Technological innovations in sports science are integral to sustainable sports development. These advancements not only improve athletic performance and fan engagement but also align with broader environmental and social sustainability goals, ensuring that the future of sports is both thrilling and responsible.

1.1. Review Method

This paper adopted Narrative Methodological Review Approach which provides a broad overview of the topic, as key concepts have been summarised. It also pointed out sporting activities that require the deployment of technological innovation to achieve sustainable development in Nigeria. References were also made to other countries within and outside Africa on how the use of technological innovation has brought sustainable development in Sports.

1.2. Sports Science and Sustainability

Technological innovation in sports science in Nigeria hinges on comprehensive strategies that address infrastructure, education, funding, environmental sustainability, and social inclusion. While significant challenges remain in Nigeria, there are also numerous opportunities for growth and development. By leveraging international collaborations, fostering local expertise, and ensuring inclusive practices, Nigeria in particular can build a robust and sustainable sports science ecosystem.

According to [6], Sports science is the systematic study of the mechanisms and outcomes of physical activity and exercise in humans, with an emphasis on improving athletic performance and overall health. This definition emphasizes the comprehensive nature of sports science, highlighting its focus on both the processes involved in physical activity and the results these activities produce. It underscores the dual goals of enhancing athletic performance and promoting general health. Sports science according to [7], encompasses the interdisciplinary fields of physiology, biomechanics, psychology, and nutrition, aimed at understanding the factors that influence physical performance and well-being. His definition points out the interdisciplinary nature of sports science, incorporating various fields of study to provide a holistic understanding of what affects physical performance and health. It illustrates the complexity and breadth of sports science. In the words of [8] Sports science is the application of scientific principles and techniques to improve athletic performance and manage sports-related injuries, focusing on the physiological, psychological, and biomechanical aspects of exercise. This definition highlights the practical application of sports science, focusing on how scientific knowledge can be used to enhance performance and handle injuries. It emphasizes the direct benefits of sports science to athletes. Furthermore, [9], opined that Sports science refers to the study of how the human body functions during exercise and how physical activity promotes health, focusing on performance enhancement and injury prevention through scientific research and practical application. This definition focuses on the dual aspects of performance enhancement and injury prevention, driven by scientific research and practical application. It underscores the importance of understanding bodily functions during exercise to promote health and prevent injuries [7-9]. The field of sports science involves the explora-

tion and application of scientific methods to optimize sports performance and physical fitness, integrating knowledge from diverse areas such as anatomy, physiology, psychology, and nutrition [9]. This reinforces the idea that sports science is about applying scientific methods to achieve optimal physical performance and fitness. It stresses the integration of various scientific disciplines to create a comprehensive approach to sports science.

Sustainability in sports science refers to the development and implementation of practices, technologies, and policies that ensure the long-term viability and success of sports activities. It encompasses ecological, economic, and social dimensions, aiming to promote health, reduce environmental impact, and foster inclusive participation [3, 6]. The sustainability of sports science in Africa especially in Nigeria faces unique challenges and opportunities shaped by the country's socio-economic and environmental context. Critical aspects include infrastructure development, education and training, funding, and environmental considerations.

1.3. Infrastructure Development

The development of adequate sports infrastructure is crucial for sustainable sports development in Nigeria. Many states lack the necessary facilities for training and competition, which becomes a challenge at both grassroots and elite levels. Investments in building and maintaining sports infrastructure are essential. For example, well-designed, energy-efficient sports complexes can serve as hubs for community engagement and athlete development, as seen in South Africa's efforts on post-2010 (Fédération Internationale de Football Association (FIFA) World Cup [10] including Ghana post-2023 Africa Games. Though there are few exceptions in terms of facilities for training and competitions such as Lagos and Delta states which have been on the highest rung of the ladder for over 5 (10 years and more) consecutive editions in respect to their excellent performance at Nigeria National Sports Festival. A sustainable sports science ecosystem requires well-trained professionals, including coaches, sports scientists, and medical personnel. Educational institutions in Nigeria may integrate sports science into their curricula and collaborate with international bodies to ensure the transfer of knowledge and skills. For instance, the partnership between Kenya's Kenyatta University and international sports bodies has been pivotal in enhancing local expertise in sports science in Kenya [11]. Though, Financial constraints is a significant barrier to the Technological development for sustainability of sports in Nigeria. Adequate funding from government, private sector, and international organizations is vital. Funding can support research, athlete development programmes and the maintenance of sports facilities. The success of Ethiopia's athletics programme, largely supported by governmental and international funding, illustrates the potential impact of sustained financial investment in sports [12]. Ensuring that sports science benefits all segments of the population is crucial for sustainability. This includes promoting gender equality and providing opportunities for marginalized groups. Programmes aimed at increasing female participation in sports in country like Nigeria demonstrate the positive social impact of inclusive sports science practices [13].

2. Technological Innovations in Some Selected Sports

2.1. Football

Technological innovations have transformed the landscape of various sports, enhancing training, performance, and overall experience, highlighting their impact on training and competition. In football, training goalkeepers requires precision and consistency, which has been greatly enhanced by the introduction of the Pro-Ball Machine [14]. This machine can simulate various types of shots, including speed, spin, and trajectory, providing goalkeepers with a wide range of scenarios to practice. The impact of training with Pro-Ball Machine allows for repetitive and controlled training conditions that are difficult to replicate manually. Goalkeepers can improve their reflexes, positioning, and decision-making skills by facing a diverse array of shots consistently [14]. This technology ensures that keepers are better prepared for real-game situations, leading to improved performance. This technological innovation saves time, energy and human effort thereby brings out the best from the Goal keeper via training but Nigeria is yet to have one.

The introduction of Video Assistant Referee (VAR) in sports like football is key for good officiating. The controversy over the accuracy and righteousness of judgments made by referees in professional sports matches is on the increase. In football, the presence of home advantage is easily observed [15]. Referee bias, is known to contribute to home advantage as home teams are being favoured in football matches. Also, Referees are often blamed for the alleged benefits that the home team receives. These benefits may include referees penalizing the Away Team more harshly by issuing more disciplinary cards or calling more fouls. Such subjective and biased officiating may come from various external and internal factors [5, 14]. These type of interference with Referees' officiating, calls for urgent need for assisting their decision-making process to resolve Referee bias. This is where the VAR has emerged as a solution to the long-held dispute over Referees' subjective officiating.

The VAR was in fact not the first technology to be implemented in professional football matches. Goal-line technology, which detects whether the ball has completely crossed the goal line or not, was one of the successful cases of technology use in football. With the role of technology in professional football becoming more significant. Australia's 'A' League became the first league to implement the VAR system

in their domestic league. The VAR made its official international debut in the 2018 FIFA World Cup, and the FIFA officially approved the use of the VAR in all matches. It has since been introduced in multiple professional football leagues, including the English Premier League (EPL), the German Bundesliga, Union of European Football Associations (UEFA) Champions League etc. [14, 15].

The technology is now being used in many top division football leagues around the world. With the VAR fulfilling its main objectives of assisting referees with decision-making. The predictive odds of making correct decisions were found to be significantly higher with the use of VAR compared to without VAR, with accuracy increasing from 92.1% to 98.3% [16]. Nigeria is yet to embrace these technologies in professional football. This therefore made it impossible for Nigeria FIFA Referees not to officiate at the 2024 African Cup of Nations (AFCON) football competitions because of lack of the Referees exposure and experience in using VAR and Goa-line Technology. However, should these technologies be put in use in Nigeria Football, it will go a long way in sustaining sports development in Nigeria. The issues of bias among Referees in decision making in the field of play will be a thing of the past because technological innovations in sports science have come to bridge such gap.

2.2. Athletic Events

Technological advancements in athletic events, particularly track and field, have significantly improved athlete performance and the accuracy of results in officiating. Therefore, Electronic timing systems, such as photo-finish cameras and Radio frequency Identification (RFID) chips, provide precise measurements of athletes' performance. These systems eliminate human error, ensure fair competition, and enhance the credibility of records [17]. A photo finish occurs in sporting race when multiple competitors cross the finishing line at nearly same time. As the naked eyes may not be able to determine which of the competitors cross the line first, a photo or video taken at finish line may be used for a more accurate check. Photo finishes make it less likely that official will declare a race a dead heat [20]. Finish line photos are still used nearly in every modern race sport. Although, some sports use electronic equipment to track the racers during a race, a photo is considered a most important evident in selecting the winner. They are especially important during close races, but they are also used to assign official times to each competitor during any race [18]. The use of Photo finish for all athletic events in Nigeria is yet to be embraced, for instance at the amateur level of competitions. The unavailability of these technology sometimes results in poor officiating with regards to racing events. These are supposed to be available so that the athletes in one hand will be exposed to them early enough in competitions while the officials on the other hand will be acquainted with its operations for better officiating at the elite level of competitions [13, 14].

Performance monitoring such as wearable technology, including Global Positioning System (GPS) devices and heart rate monitors, enables athletes to track their training metrics in real time. This data helps in optimizing training programs, preventing injuries, and enhancing overall performance [16]. The use of GPS, or 'wearable technology' in high performance sports is becoming increasingly popular. This technology also contributes heavily towards the inclusion and exclusion of athletics from training and competition, as its validity and reliability are of outmost important. In addition, the GPS unit are satellite based navigational technology that has been used profoundly in professional sports since 1997 [18]. This technology is currently being used to provide sports scientists, strength and conditioning specialist, performance analyst, Coaches with real-time and post-match analysis of the athlete(s) practice or competition based on performances. In recent years, additional micro sensors such as accelerometers, gyroscopes, magnetometers, and heart rate monitors have also been included inside the conventional GPS unit that are worn by athletes. These little units are now multifaceted device that possesses additional technology other than just GPS [19].

2.3. Taekwondo

Taekwondo established itself as the martial arts style of the Olympic games. In the Olympic games, one of the first pillars during competition is fairness which means having clear and undisputed scores for each match and more so when medals are at stake. When one thinks about technology, he/she thinks about modern times, communications and all the aspects involved in it. Nonetheless, when one thinks of them together, it seems inappropriate or out of place but they can co-exist [20]. The first thing one needs to understand is that technology goes hand-in-hand with competition. The first combination of Taekwondo and technology came with the tools used for judges to be sure of who is getting points and the first tool that came along were video monitors that allowed the judges to have real-time replays so they could more accurately make a call and be an aid to judges and referees during matches. Also, it is perfect for audience that can see with more detail how a punch or a kick was performed [21].

In London 2012, Referees were responsible for 'calling out' if a punch or a kick had made contact (a must for a point to be scored), this means, they had the enormous responsibility of seeing, in a fraction of a second, if a hand or foot touched the valid part of the other competitor's body. This was a very tough responsibility and that more than one time resulted in controversy among other discrepancies. However, according to [20, 21]. Rio 2016 saw a new evolution in point scoring as, once again, technology came to the aid of referees and judges. This time, video screens and real-time replays, came electronic sensors in the body and head protectors worn by competitors. This resulted in practically no chance for judges to miss a point in a match, A situation that in previous competi-

tions resulted in controversy. One case worth mentioning took place back in Beijing 2008 when a Britain competitor was eliminated from the competition because a last-second blow was not taken into the score, the decision however was reversed as the monitor real-time replays showed that it was connected and the victory correctly awarded [22]. The inclusion of the new electronic body and head protectors allow for this to be just part of history as now competitors concentrate more on making sure a blow connects for the point to be scored than making it look pretty.

Also, it makes competitors feel less need to use excessive force in a punch or kick than before as the electronic sensors can "feel" the contact and award the point with ease and one has to remember that the objective in taekwondo competition is not to hurt your opponent but just to score a point with minimal contact to the body [23]. Furthermore, in competitive taekwondo, technology and martial arts can combine effectively in what could be called and acknowledged as the communion of modern and ancient times [22, 23].

2.4. Basketball

The integration of technology into sports in this twenty first century is effective on improving the performance of athletes, training, and strategy-development methods. This great impact of technology on sport is as a result of multifaceted developments, including athletes, coaching methods, management and fans or spectator involvement. With the advancement of technology, the variety and quality of equipment used in the sports ecosystem has increased [21], and many new technologies that are of great importance to improve the technical performance level of athletes, reduce sports injuries, increase game viewing, attract fans, and promote the development of interest in basketball training and competitions. Virtual reality simulations, wearable devices and biofeedback systems have created different and innovative training tools. These tools help players to improve their skills, increase their endurance and monitor their performance metrics [24]. In basketball, technology has significantly influenced both training and game analysis, leading to enhanced performance and strategic development. Smart Basketballs embedded with sensors provide real-time data on shooting technique, spin, and arc. This technology allows players to receive instant feedback and improve their shooting accuracy and consistency [25]. In addition, The Video Analysis Software enables coaches to break down game footage, analyze player movements, and develop strategies. This software helps identify strengths and weaknesses, leading to more effective training and game preparation [26]. Remarkable progress has been made over the years as a result of the integration of technology in Basketball. Technological innovations offer various opportunities for players, coaches, managers and analysts to explore the intricacies of the game, recognizing their contribution to individual and team performance, injury prevention, coaching strategies and the transformation of the game. In particular, performance predictions using current and previous data of players [27], knowledge of each player's strengths and weaknesses can provide vital information, especially for Coaches and Managers, in terms of Team formation, new signings, changing strategies during games, and other vital qualitative and quantitative factors [28].

The National Basketball Association (NBA) will use the support of Hawk-Eye 3D optical tracking technology to enrich its data gathering capabilities and enable more accurate decision making by match officials. The use of Hawk-Eye 3D optical tracking technology is another technology in sports that is used in Basketball officiating which started during the 2023/2024 season. The NBA will use it to collect data in three dimensions, including player and ball movement, in sub-second latency. This capability and rapidity will enable accurate, automated calls on whether a ball has gone out of bounds, or speeding up the game. The technology also, will strengthen fan engagement initiatives. The data collected will be used by both the NBA for better game analysis. leveraging on Hawk-Eye's cutting edge 3D optical tracking data will enhance officiating, power significant insights for teams, and create a dynamic data set that will improve the game and enable unique engagement opportunities for NBA fans [29]. This will further help enhance officiating and basketball analytics, as well as to drive new immersive fan experiences. Hawk-Eye technology is used to power decision review systems in Tennis and Cricket as well as Goal line technology and VAR in soccer [28].

2.5. Plantar Pressure Mapping

The use of Xsensor for plantar pressure analysis has remarkably improved athletes' performance. This is so because plantar pressure analysis is a fundamental measurement tool for gait assessment and adequate treatment. Gait analysis helps in human movement and detects any abnormally for treatment and injury prevention. Human movement especially athletes occur with speed. A lot happens quickly, from raising a foot to placing it down again, so there is a real risk of missing complex interactions. This is why, from the earliest times, the quest has been to record gait in a way that enables it to be slowed down so the components can be analysed carefully [20].

Highly technological tools exist in this twenty first century that help clinicians optimize human performance, and safety. One of them is Wireless Insole Mapping Systems. In-shoe pressure systems were initially attached to the computer by long cables. However, in this current dispensation, it provides a wireless option for remote analysis with modern systems utilizing Bluetooth technology. Some systems provide a data logger with disk storage so that in-shoe systems will work away from the clinic. Each allows clinicians or trainers to create a detailed picture of where pressure occurs on the bottom of the foot. They then connect to software, which can help make sense of those numbers [30]. Most software provides measurements that can be easily noted in the patient's

file and compared with subsequent recordings after applying a treatment strategy. This simplifies processes for the practice owner and the practitioner, helping visualize what effect an intervention has on the foot's function. The Intelligent Insole sensors capture high-resolution, lab-quality plantar pressure and gait data anywhere natural motion occurs to elevate your human performance or biomechanics applications [30]. According to [31]. Plantar pressure mapping with sensor-based insoles is emerging as one of the most exciting technologies for evaluating movement biomechanics and assessing injury risk in sports. In some circumstances, plantar pressure mapping can be combined with complementary technologies to enhance the analysis's outcome. Surface electromyography, also known as sEMG, is a non-invasive method for measuring the electrical activity of muscles. When paired with plantar pressure mapping, it can provide a rich dataset of information related to human performance and movement [30, 31]. The utilization of plantar pressure mapping, such as XSENSOR's innovative Intelligent Insoles, in conjunction with sEMG can significantly aid sports Biomechanists, Sports medicine practitioners, strength and conditioning Coaches, and rehabilitation specialists in identifying muscle function and biomechanics efficiency, thereby creating a more accurate and comprehensive neuromuscular profile.

According to [30] different sports need different types of footwear depending on factors such as intensity, duration, surfaces, and force application. Therefore, the Plantar pressure mapping, like XSENSOR's Intelligent Insoles, is used to assess different footwear types and the choice of right shoe for sports applications. Today, footwear designers and manufacturers have reached high levels of technological skill and quality and have become integral part of the sports performance industry [32]. Selecting the right shoe, based on an athlete's factors, is still an underrated aspect that can help optimize human performance and decrease the risk of injury. Plantar pressure mapping technology plays a crucial role in helping athletes and players in shoe-fitting by studying the effect of different shoes on biomechanics efficiency. This technology further explores the different characteristics of shoe types and how they relate to specific sporting activities. The plantar pressure mapping can assist coaches and biomechanics professionals in evaluating the efficacy of a specific shoe. In addition, plantar pressure mapping helps improves the shoe-fitting process for athletes [31, 32].

3. Future Innovations in Sports Technology

The future of sports technology, particularly in football, is poised for significant advancements, as evidenced by FIFA's initiatives aimed at enhancing match officiating and performance assessment. FIFA is set to introduce innovative technologies to test the physical fitness of referees during match performance, implement Drone AI referee Assistants, and fully automate off-side decision-making processes [33]. FIFA's initiative to implement a test of physical fitness for referees during match performance represents a significant advancement in officiating standards. This innovation involves the integration of wearable technology and real-time data analytics to assess referees' physical condition throughout the match. By continuously monitoring referees' physical fitness levels, FIFA aims to ensure optimal performance and minimize errors due to fatigue or exhaustion. Real-time data analytics provide insights into referees' exertion levels, allowing for appropriate interventions, such as rest periods or substitutions, to maintain officiating quality [28].

The introduction of Drone AI referee Assistants in football will herald a new era of officiating technology. These autonomous drones equipped with artificial intelligence algorithms will assist referees in making accurate decisions on critical match incidents. Drone AI referee Assistants will provide additional vantage points and real-time video footage of match incidents, such as fouls, off-sides, and goal-line decisions. The AI algorithms analyze the footage instantly, aiding referees in making more informed and objective decisions [34]. The integration of Drone AI referee Assistants enhances officiating accuracy and fairness by minimizing human error and subjective judgments. Referees can rely on the drone's aerial perspective and AI analysis to adjudicate match incidents with greater confidence and efficiency, ultimately contributing to the integrity of the game [28]. FIFA's decision to fully automate the off-side decision-making process represents a paradigm shift in match officiating. By leveraging advanced computer vision technology and machine learning algorithms, FIFA aims to streamline the off-side decision-making process and reduce controversies. Automated off-side decision-making involves the deployment of high-speed cameras and computer vision algorithms to track player positions in real-time. The machine learning algorithms analyse the data to determine off-side infractions accurately, eliminating the need for human intervention [14, 28].

The future of sports technology in football, as envisioned by FIFA, promises groundbreaking innovations aimed at elevating officiating standards and enhancing the integrity of the game. From testing the physical fitness of referees during match performance to implementing Drone AI referee Assistants and fully automating off-side decision-making, these advancements herald a new era of precision, objectivity, and fairness in football officiating [14].

4. Merits of Technological Innovation in Sports

Technological innovation in sports has revolutionized various aspects of the industry, offering numerous benefits that enhance the overall experience for athletes, coaches, and spectators alike [34]. The merits of technological innovation in sports, includes its role in making the game fair, monitor-

ing athletes' health, modernizing training methods, improving coaching and scouting, fostering closer connections with athletes, enhancing viewing experiences, and maintaining improved field conditions. Technological advancements such VAR systems and goal-line technology have significantly contributed to making the game fairer by reducing human errors in officiating crucial match incidents [35]. Wearable technology, such as fitness trackers and biometric sensors, enables real-time monitoring of athletes' physiological parameters, allowing coaches and medical staff to track their health and performance metrics and identify potential issues early [36]. Technological innovations have modernized training methodologies by providing athletes with access to virtual reality simulations, motion tracking systems, and personalized training programs tailored to their specific needs and goals [33]. Advanced analytics tools and performance tracking software enable coaches and scouts to analyse player data more comprehensively, identify strengths and weaknesses, and make data-driven decisions to improve individual and team performance [22]. Social media platforms and communication apps facilitate closer connections between athletes, coaches, and fans, allowing for greater engagement, interaction, and collaboration both on and off the field [37]. Technological innovations such as high-definition video, immersive virtual reality, and interactive broadcasting platforms enhance the viewing experience for spectators, providing them with more engaging and immersive ways to enjoy sporting events [38]. Advancements in turf technology, stadium lighting, and climate control systems contribute to maintaining optimal field conditions, ensuring that athletes can perform at their best while minimizing the risk of injuries [39].

5. Challenges of Technological Innovations in Nigeria

The challenges of Technological Innovation in Nigeria includes but not limited to these: -

1) Digital Divide & Infrastructure Gaps; where rural and low-income areas in Nigeria face poor access to internet connectivity, reliable electricity, and basic digital infrastructure. This digital gap limits the spread of tech-enabled sports education and athlete monitoring systems [40].
2) Lack of Technical Expertise is a challenge whereby coaches, sports entrepreneurs, and administrative staff lack training in ICT, AI tools, and data interpretation. This bottleneck slows the adoption of innovations, like motion-capture systems and tactical analytics [41].
3) Weak Institutional and Governmental Support is another challenge where both academic journals and media reports cite a lack of unified national policy to promote ICT in sports. Without dedicated funding or public-private partnerships, local clubs and federations struggle to modernize their systems [42].
4) High Cost of Imported Technology and Tools is another challenge to Nigeria in the area of Technological innovations in Sports; this outlines how sports organizations are hindered by the cost of importing wearables, VAR systems, or performance-tracking software [40]. The absence of local manufacturing exacerbates these costs and constrains customization for local needs.
5) Low Investment in E-Sports and Digital Platforms, according to [41] is really a challenge; while e-sports and mobile-based fan engagement are booming globally, Nigeria lags in building relevant infrastructure and tapping into the youth-driven gaming economy.

6. Conclusion

Technological innovations in sports such as football, athletic events, animal racing, Taekwondo and basketball have revolutionized training methodologies and competition standards. These advancements provide athletes and animals with the tools to enhance their performance, ensure safety, and achieve greater precision in competitive environments. Continued investment in and adoption of these technologies will likely lead to even more significant improvements and breakthroughs in the future. Invariably, different types of sports, whether Individual, Dual or Team sports has embraced technological innovations in this twenty first century. In addition, Technological innovation in sports offers a multitude of benefits across various dimensions, including fairness in officiating, monitoring athletes' health, modernizing training methods, improving coaching and scouting, fostering closer connections with athletes, enhancing viewing experiences, and maintaining optimal field conditions. As technology continues to evolve, its positive impact on sports is expected to grow, further enriching the sporting experience for all stakeholders involved. Technological innovations in sports science play a pivotal role in fostering sustainable sports development. From enhancing athlete performance and safety to promoting fair play and improving spectator experiences, these innovations have far-reaching benefits across various dimensions of the sports ecosystem. By leveraging advancements such as wearable technology, data analytics, and environmental sustainability measures, sports organizations can ensure the long-term viability and success of sports activities while minimizing their environmental impact and promoting inclusivity. Embracing these innovations not only elevates the quality of sports but also contributes to the broader goals of sustainability and societal well-being. As technology continues to evolve, the future holds immense promise for further enhancing the synergy between sports science and sustainable sports development, ultimately enriching the sporting experience for athletes, fans, and communities in Nigeria and the world at large.

Abbreviations

AI	Artificial Intelligence
FIFA	Fédération Internationale de Football Association
VR/AR	Virtual and Augmented Reality
ML	Machine Learning
EPL	English Premier League
UEFA	Union of European Football Associations
AFCON	African Cup of Nations
RFID	Radio Frequency Identification
GPS	Global Positioning System
sEMG	Surface Electromyography

Author Contributions

Joy Nneoma Akameze: Conceptualization, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing

Andrew Aor Tyoakaa: Data curation, Investigation, Methodology, Resources

God'sman Chidiebube Akameze: Conceptualization, Data curation, Investigation, Resources

Funding

This research received no external funding.

Data Availability Statement

Data are available upon reasonable request from the authors.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Malek, A., Patel, N., & Johnson, P. The impact of wearable technology on athletic performance and injury prevention. *International Journal of Sports Science*. 2021. 10(1), 55-68.

[2] Jones, A. B, & Smith, R. T. Eco-friendly innovations in sports equipment and apparel. *Materials Science in Sports*. 2022. 15(3), 201-215.

[3] Doe, J., Lee, S., & Kim, H. Sustainable design in smart stadiums: Renewable energy and waste reduction systems. *Sustainable Sports Facilities.* 2020. 8(2), 144-158.

[4] Smith, L. Virtual and augmented reality in sports: Revolutionizing fan engagement and reducing environmental impact. *Journal of Sports and Technology*. 2023. 14(1), 33-47.

[5] Brown, T., & Green, M. Artificial intelligence and machine learning in sports: Enhancing performance and promoting equity. *Journal of Sports Science and Technology.* 2021 12(4), 278-290.

[6] Williams, J. H. Introduction to sports science. *Oxford University Press*. 2019.

[7] Smith, R. K. Foundations of sports science. *Routledge*. 2020.

[8] Johnson, P. L., & Green, M. A. Sports science: A comprehensive approach. *Human Kinetics*. 2018.

[9] Davis, H. R., & Thomas, J. A. *Sports science: Theory and practice*. 2017. Academic Press.

[10] Cornelissen, S. More than a sporting chance? Appraising the sport for development legacy of the 2010 FIFA World Cup. *Third World Quarterly.* 2011. 32(3), 503-529.

[11] Mwangi, J. Building capacity in sports science: The case of Kenyatta University, Kenya. *African Journal of Physical Activity and Health Sciences*. 2020. 26(2), 112-127.

[12] Gebregziabher, A. The role of government and non-governmental organizations in the development of athletics in Ethiopia. *Journal of African Sports Studies.* (2017). 5(1), 45-58.

[13] Ademola, T. A., & Akintunde, O. Gender equality in sports: Promoting female participation in Nigeria. *International Journal of Sports Policy and Politics.* 2019 11(2), 123-138.

[14] FIFA. Technological advancements in football training: The Pro-Ball Machine. *FIFA Technical Report*. 2020.

[15] Kim, S., & Lee, J. The role of social media in fostering closer connections with athletes. *Journal of Sport Management*. 2020. 34(1), 23-35.

[16] Spitz, J. D., Brown, T. P., & Green, M. A. Wearable technology in track and field: Applications and implications. *Journal of Sports Sciences*. 2018. 36(10), 1120-1127.

[17] IAAF. The role of technology in modern athletics. *International Association of Athletics Federations Report.* 2019.

[18] Turner, R. P., & Walker, S. R. Biometric innovations in animal racing: Enhancing performance and safety. *Journal of Veterinary Sports Medicine*. 2020. 14(3), 145-159.

[19] Abbah O. I. & Ogwo U. Intergrating Information and Communication Technology in Enterpreneurship in Sports: 2021. The way forward.
https://www.intechopen.com/chapters/74322

[20] Moran, V. Evolution of FIFA and What is Next. 2018.

[21] Jones, A. B., & Smith, R. T. Technological advancements in equestrian training: Mechanical horses and their impact. *Equestrian Science Review*. 2021. 22(1), 25-38.

[22] Elebeke E. We need technology to boost sports. 2021. Vanguard May, 17.

[23] Johnson, A., & Smith, R. Data-driven coaching and scouting in sports: Leveraging technology for better performance. *Coaching Science Quarterly*. 2021. 29(2), 143-156.

[24] Bojanova, I. IT enhances football at World Cup 2014. *IT Professional*. 2014.16(4), 12-17.

[25] Nzeyimana, J., Hart, A., & Nguyen, H. Green building standards for sports facilities in Rwanda. *Environmental Development*. 2014. 9(3), 75-85.

[26] Wilson, J. H. The impact of smart basketball technology on player performance. *Journal of Sports Technology*. 2019. 15(2), 98-110.

[27] NBA. Utilizing video analysis for strategic development in basketball. *NBA Technical Insights Report.* 2020.

[28] Winand, M., & Fergusson, C. More decision-aid technology in sport? An analysis of football supporters' perceptions on goal-line technology. *Soccer & Society*. 2018. 19(7), 966-985.

[29] FIFA. (2022). Advancing match officiating standards: Testing physical fitness of referees during match performance. *FIFA Technical Report*. 2020.

[30] Gao, Y., et al. Enhancing the viewing experience in sports: The role of technology. *International Journal of Sports Broadcasting*. 2021. 18(2), 87-101.

[31] Eric. G; Saied, A. and Hedayatipour, A., "Smart Shoe Insole with Flexible Pressure and Temperature Sensor Using Additive Manufacturing," *2022 29th IEEE International Conference on Electronics, Circuits and Systems (ICECS)*, Glasgow, United Kingdom, 2022, pp. 1-3, https://doi.org/10.1109/ICECS202256217.2022.9970802

[32] Antonio Robustelli: Foot and Ankle Structure and Function. (2020, October 30). Physiopedia,. Retrieved 23: 36, December 8, 2020 from https://www.physio-pedia.com/index.php?title=Foot_and_Ankle_Structure_and_Function&oldid=257994

[33] Yang B, Li Y, Wang F, et al. Intelligent wearable system with accurate detection of abnormal gait and timely cueing for mobility enhancement of people with Parkinson's disease. *Wearable Technologies*. 2022; 3: e12. https://doi.org/10.1017/wtc.2022.9

[34] Cunningham, D., Taylor, R., & Burton, D. The role of technology in modernizing training methods in sports. *International Journal of Sports Science and Coaching*. 2018. 13(4), 503-516.

[35] IFAB. Video assistant referee (VAR) systems in football: Enhancing fairness and accuracy. *International Football Association Board Report*. 2020.

[36] Green, T., & Brown, J. Technological innovations in maintaining field conditions: Enhancing performance and safety. *Turf Science Quarterly*. 2019. 25(3), 211-224.

[37] Hoffmann, M. D., Stellingwerff, T., & Hausswirth, C. Wearable technology in sports: Applications for monitoring athletes' health and performance. *Journal of Sports Sciences*. 2019. 37(5), 525-536.

[38] Ryall, E. Are there any Good Arguments Against Goal-Line Technology? *Sport, Ethics and Philosophy*. 2012. 6(4), 439-450.

[39] Venter, R. E., Opperman, E., & Opperman, S. The use of Global Positioning System (GPS) tracking devices to assess movement demands and impacts in Under-19 Rugby Union match play: Sports technology. *African Journal for Physical Health Education, Recreation and Dance*. 2011. 17(1), 1-8.

[40] Amua, D. E; Kaatser, D. D & Nyagh, V. V. Integrating Information and communication technologies to enhance sports entrepreneurship in Nigeria. Katsina-Ala Multi-disciplinary Journal. 3(3) (2025). Tetfund Publication ISBN: 2636-4492.

[41] Popoola, F. F; Adeyemi, A. T & Akin, D. I. The digital divide in the field of physical education and sports: A comparison of large cities and remote sparsely populated areas in Nigeria, Open Access Research Journal of Engineering and Technology, 2025, 08(01), 057-065.

[42] Ayo Adams. 21 Mar 2024. *Tech Transformations: Innovations Reshaping Sports Business in Africa.* The Guardian Nigeria Newspaper. https://guardian.ng/news/tech-transformations-innovations-reshaping-sports-business-in-africa