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Analysis of the Use of Technology in Modern Sports

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Abstract. The development of computer-related technologies, such as artificial intelligence, deep learning, VR, and big data, has optimised the operational rules of various industries through their application. Within the sports industry, the growing integration of computer technology and sports has driven transformative changes in the sports industry in terms of training, strategy, officiating, and fan engagement. This paper investigates the impact of technologies such as wearable devices, virtual reality (VR), data analytics, and biomechanics on modern sports. Using a literature review and case-based analysis, it explores how these technologies optimize athletic performance, reduce injury risks, support strategic decisions, and reshape audience experience. While highlighting their advantages, the study also addresses ethical concerns and the emerging inequality between resource-rich and resource-poor teams. The research findings indicate that these technologies have comprehensively enhanced the level of sports in terms of athlete performance and protection, competitive strategies, and experiences. However, maintaining fairness and balancing these technologies with human-centred values is equally crucial.

Keywords: Sports technology, Wearable devices, Virtual reality training, Data analytics, Biomechanics

1. Introduction

Technology is one of the most essential components of modern sports, affecting the manner in which sports are participated in and experienced from a variety of perspectives, including athletes' training methods, coaches' game plans and tactical planning, referees' decisions, and spectators' viewing experiences. Tools such as wearable devices, video review systems, virtual reality technology and data analytics have sparked discussions about the nature and fairness of sport while enhancing athletic performance and ensuring fairness. Through literature review and theoretical analysis, this paper explores the help provided by different technological applications and the problems they may bring, based on the current application of computer technology in sports [1].

By revealing the interaction between technology and sport, the paper summarizes the possibilities that technological upgrading brings to sports activities, and also provides suggestions and support for the proper use of science and technology to maintain sustainable development.

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2. Application

2.1. Wearable technology

One of the notable changes in the use of computer-related technologies in sports is the monitoring of athletes' status during training and competition. Wearable technologies such as GPS trackers and heart rate monitors provide coaches with a wealth of data on running speed, fatigue levels, and injury risk warnings. This helps coaches develop scientific training programs that enhance athletes' performance and reduce injury rates. In addition, devices such as WHOOP and Oura Ring can track and record athletes' sleep quality, condition recovery, and stress, allowing athletes to achieve refined health management even during non-training hours [2,3].

Technology is also changing the way referees make calls. The VAR (Video Assistant Referee) system in soccer and the Hawk-Eye technology in tennis both use video replay to ensure the accuracy of referees' decisions, thereby improving the fairness of the game. However, there are some problems with the actual use of these technologies. For example, in soccer matches, some spectators think that VAR slows down the pace of the game and reduces the excitement of watching the match. In addition, even with the use of video to enhance the transparency of the game process, it is still difficult to reach a consensus on certain complex penalties. This shows that although technology can help, it cannot solve all problems. The application of technology needs to strike a balance between accuracy and the smoothness of the game [4].

2.2. VR and training

Virtual Reality (VR) and simulation are disrupting the traditional training model. With VR equipment, athletes can simulate real game situations in virtual scenarios with zero risk of injury. The three core advantages of VR training are: high-frequency repetitive training with zero wear and tear, data-driven precision optimization, and risk avoidance in all scenarios [5].

For example, simulated defensive formations and game pressure scenarios loaded onto a VR training system help American football players improve their pass anticipation accuracy in a near-formal game environment. Soccer players use VR glasses and sensors to simulate extreme weather conditions, such as rainstorms and blizzards, to personalize training programs and improve athletes' ability to adapt to the field of play [6]. In athletics, VR technology provides relay athletes with the opportunity to focus on optimizing the accuracy of the baton handover, reducing the starting error while avoiding the risk of injury and providing key technical support to improve performance. In addition, basketball players can wear VR headsets for shooting training, the system real-time display of the best shooting trajectory and posture adjustment recommendations, and through the motion sensor to analyze the shooting angle, force and inertia data, thereby improving the athletes' hitting rate. Skiers can adapt to complex track conditions indoors in advance through VR ski simulators and pressure sensors, and make timely corrections to the athlete's training. Toptracer technology in the golf field has realized a 1:1 reduction of famous courses in the virtual world, allowing practitioners to experience top tracks such as Pebble Beach at any time [7]. This type of training not only breaks through the limitations of physical training, but also accelerates skill iteration through immersive experiences, making “safe and efficient improvement” possible.

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2.3. Data analysis

Data analytics is now a core driver in sports, with teams building personalized data-driven decision-making systems by capturing massive amounts of game data. According to baseball's "Moneyball" theory, the application of statistical modeling can create both economical and competitive lineups with limited budgets, which subverts the traditional sports decision-making model that relies on experience and intuition [8]. Today, this "data-first" mentality has permeated soccer, basketball, rugby, and other mainstream sports, and has become a standard in professional sports around the world.

Based on the development and application of big data models, the in-depth empowerment of artificial intelligence (AI) has further amplified the value of data, which is now used as the main training basis for athletes' training and coaching in various countries. Through machine learning algorithms to parse complex data networks, AI can not only provide coaching staff with offensive and defensive strategy suggestions, but also predict hidden dangers such as muscle strain and fatigue accumulation through injury risk models, so that preventive training can be accurate to individual players. In addition, scouts are no longer limited to on-site observation of the game, but use AI tools to conduct multi-dimensional scanning of game videos, historical data, and even the results of player psychological evaluations, which also greatly increases the opportunity for players in their formative years or talented players who don't go out to get attention [7].

For fans, AI can provide real-time updates, personal content, and smart replays. Watching sports has become more interactive with more ways to enjoy and understand the game. The intelligent transformation of the spectator experience is also enabled by the combination of data and AI. Through AI, the viewing platform captures 100+ dimensions of data such as players' running speed and passing success rate in real time, and superimposes them on the live broadcast screen in the form of dynamic charts, allowing viewers to instantly understand the trend of the game. Meanwhile, based on the user's historical viewing preferences, AI can customize exclusive content for the audience, such as the tactical enthusiasts to break down the logic of the offensive and defensive transitions of a particular game. Its intelligent replay system can identify key events (such as goals and controversial penalties) and generate multi-camera slow-motion replays in a short period of time, with relevant data annotations, transforming passive game watching into an interactive experience that is both informative and engaging [9-10].

2.4. Biomechanics

Biomechanics is becoming a "sports microscope" in the field of sports. By analyzing the human body's movement patterns through high-speed cameras and motion sensors, coaches and scientists are able to capture the subtle deviations in running, jumping, swimming, throwing, and other movements. For example, in sprint training, the system can detect the problem that the athlete's knee extension is less than 0.5 degrees during the start through the joint angle sensor. After targeted adjustment, the reaction time of the start can be reduced by 0.03 seconds [11]. Through 3D motion capture, the frequency of the swimmer's stroke and the angle of the body roll can be detected, increasing energy efficiency by up to 7%. These technologies are not only used to optimize sports performance, but also to build a scientific closed loop for injury prevention and rehabilitation. By monitoring the symmetry of muscle strength in real time, 85% of potential strains can be warned in advance. And in the post-injury rehabilitation phase, pressure sensor insoles can accurately quantify the progress of the foot's weight-bearing recovery, reducing the rate of miscalculation of return to play by 60% [11].

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But technological breakthroughs often come with questions about the fairness of the game. For example, “sharkskin” swimsuits, which have helped athletes set multiple world records, were banned by FINA on the grounds that their bionic structure greatly reduces water resistance, bringing bad publicity to the competition [12]. This controversy over the application of technology also highlights the paradox of sports science and technology. When the performance of the equipment challenges the limits of human physiology, is the nature of the competition a “challenge to human potential” or a “technological arms race”? From microscopic muscle power trajectories to macroscopic iterations of equipment materials, biomechanics and technological equipment are redefining the boundaries of “faster, higher, stronger.” However, like the IAAF's restrictions on spike length in running shoes and Formula 1's regulations on downforce in race cars, the sports world has always sought a dynamic balance between technological innovation and fair play.

Biomechanics is another tool used in sports. This means using cameras and sensors to study how the body moves. Coaches and scientists watch how athletes run, jump, swim, or throw. They can spot small problems in the movement and help the athlete improve. This also helps prevent injuries. After an injury, the same tools can be used to check if the athlete is ready to return to play safely. Equipment has also changed a lot. New materials such as carbon fiber have made racquets, bikes and shoes lighter and stronger. In swimming, special suits that helped athletes swim faster were later banned because they were too powerful.

3. Potential issues

Fans now enjoy sports in new ways. Stadiums have big screens, free Wi-Fi, and apps that show stats and replays. At home, fans can watch games with smart cameras, slow motion, and live data on screen. Drones give cool views from above, and new cameras show every angle. This makes watching more fun and helps fans feel closer to the game [9].

The explosive development of sports technology is impacting the traditional view of fairness. While new equipment significantly improves sports performance, rule iterations often lag behind technological innovations, exposing a deep-seated contradiction between “technological empowerment” and “fair competition”. The deeper problem lies in the Matthew effect of technological resources. The significant difference in technological investment between top league teams and lower level teams has led to the evolution of the gap between the strong and the weak from “player ability” to a “technological arms race”. This divide is particularly prominent in youth sports. Developed regions generally introduce intelligent monitoring equipment into their youth training systems, while less developed regions still face a lack of basic equipment, and the technological gap is reshaping the “talent” screening mechanism [13].

In addition, technology allows viewers to analyze the game from a “God's point of view” and to interact with multi-dimensional data in real time. But this experience is also dissolving the original charm of sports. Some viewers have expressed dissatisfaction with technology interfering with the pace of the game, believing that it has diluted the emotional tension of live viewing. Traditional tournaments such as Wimbledon insist on manual scoring, retaining the sense of ceremony that “misjudgment is also part of the athletic narrative”, reflecting the fact that the temperature of sports is not only in the accuracy of data, but also in the unpredictable light of human nature [9].

In the field of youth sports, technological intervention is also rewriting the nature of “happy sports”. The introduction of real-time movement monitoring and performance scoring in some youth training systems, while improving training efficiency, may weaken the improvisational creativity of young athletes, and go against the possibilities of discovering the body in uninhibited movement.

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4. Conclusion

Integrating technology into sport is both a revolutionary leap forward and a complex paradox. Innovations such as wearables, VR training, data analytics and biomechanical tools have radically improved athletic performance, decision-making accuracy and spectator engagement. However, the proliferation of technology has exposed systemic inequalities. Funding gaps between countries create an unbridgeable "technological divide" that threatens the balance of competition. An overreliance on data also threatens to erode the intuition and humanism of sport. Ultimately, sport is a testament to human ambition, resilience, and collective spirit. Technology, when used thoughtfully, can enhance these values by unlocking new areas of human potential.

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