Research on the Construction and Application Innovation of Smart Sports Training Scenarios Driven by Digital Intelligent Technology

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ABSTRACT Against the backdrop of deep integration between digital intelligent technologies and the sports industry, traditional sports training models are plagued by prominent drawbacks including homogenization, insufficient precision and weak data support. Smart sports training has evolved into a core trend for the scientific development of sports. Centered on the upgrading of sports training scenarios empowered by digital intelligent technologies, this paper analyzes the current development status and existing problems of smart sports training scenarios, constructs a multi-layer, multi-sub-scenario smart sports training system, explores its innovative application paths, analyzes application effects through empirical research, and puts forward targeted optimization strategies. The research demonstrates that digital intelligent technologies including the Internet of Things (IoT), big data, artificial intelligence (AI) and digital twins can effectively resolve pain points of traditional sports training and realize the upgrading of personalized training, dynamic monitoring and integrated training-competition systems. Nevertheless, prevailing challenges such as homogenized scenarios, incomplete data systems and insufficient deep integration of technologies still remain. In the future, standardized construction, in-depth technological empowerment and industry-university-research collaborative development will promote the large-scale and refined development of smart sports training scenarios, providing theoretical references and practical support for the digital transformation of sports training.

INDEX TERMS Digital Intelligent Technology, Smart Sports, Training Scenarios, Scenario Construction, Application Innovation

I. INTRODUCTION

A. RESEARCH BACKGROUND AND SIGNIFICANCE

1) RESEARCH BACKGROUND

Amid the comprehensive advancement of the national digital economy strategy, digital intelligent technologies such as artificial intelligence, big data, the Internet of Things and digital twins have accelerated penetration across all industries, driving the digital and intelligent transformation and upgrading of various sectors[1].

The General Administration of Sport of China has successively issued policy documents including the Outline of the National Fitness Program and the Implementation Plan for the Digital Development of the Sports Industry. These documents explicitly call for advancing the scientific and intelligent development of sports training, constructing new sports training scenarios based on digital technologies, and improving the quality and efficiency of sports training[2].

Traditional sports training has long relied on coaches'experience, accompanied by shortcomings such as homogenized training programs, fragmented process monitoring and subjective effect evaluation. Such a model fails to meet the development demands of precise training in competitive sports and scientific fitness for mass sports.

Against the backdrop of increasingly fierce competition in competitive sports and continuously rising demand for national fitness, reconstructing sports training scenarios and innovating training models via digital intelligent technologies has become an inevitable path to break bottlenecks in traditional training and boost high-quality development of sports undertakings[3].

Under such circumstances, the system construction and application innovation of smart sports training scenarios have emerged as key research topics in the field of digital sports.

2) RESEARCH SIGNIFICANCE

Theoretical Significance: This paper clarifies the core connotations of digital intelligent technologies and smart sports training, constructs a theoretical framework for the integration of technologies and sports training, improves the

research system for scenario-based construction of smart sports, and fills gaps in systematic research within relevant fields.

Practical Significance:

By establishing a multi-dimensional smart training scenario system, this research effectively addresses the issues of homogenization, low precision and insufficient scientificity in traditional sports training.

It can provide intelligent practical solutions for competitive training, campus sports and mass fitness, facilitating the digital and high-quality development of sports training.

B. DOMESTIC AND OVERSEAS RESEARCH STATUS

1) OVERSEAS RESEARCH STATUS OF SMART SPORTS TRAINING

Research on smart sports training started earlier overseas with mature technological implementation systems. Countries in Europe, America, Japan and South Korea have widely applied IoT, artificial intelligence and virtual simulation technologies in competitive sports training, forming data-driven and standardized intelligent training models[4-6]. They boast rich experience in equipment application, refined scenario operation and industrial norm formulation, yet their research findings cannot be fully adapted to China's sports training development system.

2) DOMESTIC RESEARCH STATUS OF SMART SPORTS TRAINING

Domestic research on smart sports has achieved rapid progress in recent years with continuously improved digital infrastructure. Intelligent training equipment and big data analysis technologies have been gradually applied in sports training[7, 8]. Current domestic research mostly focuses on fragmented exploration of single technologies and individual sports events, which has verified the empowering value of digital technologies. However, systematic construction of scenario architectures and long-term operation research are generally lacking, and the theoretical system and application mechanism remain imperfect.

Overall, there exists a research gap in systematic construction, multi-dimensional innovation and long-term optimization of smart sports training scenarios driven by digital intelligent technologies, which creates room for this study.

C. RESEARCH CONTENT

a. Define core concepts and sort out relevant theories and technical systems of digital intelligent technologies and smart sports training;

b. Analyze the current development status and core existing problems of smart sports training scenarios;

c. Construct a smart sports training system with multi-layer technical architectures and multi-sub application scenarios, and build supporting operation guarantee mechanisms;

d. Explore innovative directions of scenario application, analyze application effects, propose strategies for scenario optimization and upgrading, and prospect the future development trends of the industry.

II. DEFINITION OF CORE CONCEPTS AND THEORETICAL & TECHNICAL FOUNDATIONS

A. DEFINITION OF CORE CONCEPTS

1) DIGITAL INTELLIGENT TECHNOLOGY

Digital intelligent technology refers to a cluster of technologies relying on digital infrastructure to realize data collection, transmission, processing, analysis and intelligent application, with core components including the Internet of Things, big data, artificial intelligence, digital twins and cloud computing[9].

This technical system features comprehensive perception, precise data, intelligent analysis and rapid iteration. It enables digital reproduction, dynamic monitoring and intelligent decision-making of physical scenarios, serving as the core technical support for the digital transformation of traditional industries.

2) SMART SPORTS TRAINING

Smart sports training is an innovative sports training model centered on digital intelligent technologies and grounded in scientific sports training theories. It collects full-dimensional training data, intelligently analyzes training patterns and dynamically optimizes training programs to achieve precise training processes, personalized training plans and scientific training evaluation. It covers multiple fields including special training for competitive sports, mass scientific fitness and campus physical education training[10].

3) DIGITAL CONSTRUCTION OF SPORTS TRAINING SCENARIOS

The digital construction of sports training scenarios refers to the digital reconstruction of venues, equipment, training processes and evaluation systems of traditional sports training supported by digital intelligent technologies. It builds intelligently integrated training scenarios combining virtual and physical elements driven by data and dynamically adaptive, realizing full-process perceptibility, quantifiability, analyzability and optimizability of training. It serves as the core carrier for the transformation from traditional sports training to smart sports training[11].

B. CORE SYSTEM OF DIGITAL INTELLIGENT TECHNOLOGIES

1) INTELLIGENT PERCEPTION AND INTERNET OF THINGS TECHNOLOGY

As the data entry point of smart training scenarios, intelligent perception and IoT technologies collect multi-dimensional data in real time, including athletes' heart rate, cadence, movement posture, training load and venue environment via wearable sensors, venue intelligent monitoring devices, motion capture cameras and other terminals. They realize comprehensive and real-time perception of the entire

training process and provide raw data support for subsequent data analysis[12, 13].

2) BIG DATA AND ARTIFICIAL INTELLIGENCE ANALYSIS TECHNOLOGY

Big data technology cleans, integrates, stores and manages massive training data to resolve the fragmentation and low reusability of traditional training data[14]. Artificial intelligence technology applies machine learning and deep learning algorithms to conduct intelligent analysis on training data, automatically identify movement errors, evaluate training loads, predict sports risks, generate personalized optimized training programs and realize intelligent decision-making[15].

3) VIRTUAL REALITY AND DIGITAL TWIN TECHNOLOGY

Virtual reality and digital twin technologies can construct immersive simulated training scenarios integrating virtual and physical elements, reproducing competition venues and special training scenarios for athletes to conduct immersive simulated training. Meanwhile, they enable digital twin reproduction of physical training scenarios, real-time mapping of training status and dynamic optimization of scenario parameters, improving the authenticity and pertinence of training.

4) CLOUD COMPUTING AND EDGE COMPUTING TECHNOLOGY

Cloud computing provides storage and computing power support for massive training data, realizing data resource sharing and remote management. Edge computing completes real-time data processing at training terminals to reduce data transmission delay, guarantee timeliness of dynamic training monitoring and real-time error correction, and improve the operational efficiency of smart training scenarios[16].

III. DEVELOPMENT STATUS AND PROBLEM ANALYSIS OF SPORTS TRAINING EMPOWERED BY DIGITAL INTELLIGENT TECHNOLOGIES

A. DEVELOPMENT STATUS OF SMART SPORTS TRAINING SCENARIOS

1) DIGITAL TRANSFORMATION TREND OF SPORTS TRAINING

The digital transformation of sports training in China is accelerating continuously with increasing policy support and improved digital infrastructure. Smart sports training has gradually shifted from conceptual frameworks to practical applications.

Intelligent training equipment has gained popularity in competitive sports, campus sports and mass fitness sectors.

The industry has widely recognized the concept of digital and intelligent training, and sports training is transitioning from "experience-driven" to "data-driven".

2) APPLICATION STATUS OF DIGITAL INTELLIGENT TECHNOLOGIES IN SPORTS TRAINING

At present, digital intelligent technologies have been extensively applied in monitoring, evaluation and simulation links of sports training. IoT perception technologies are commonly adopted for real-time physical fitness data monitoring; artificial intelligence technologies are gradually applied in movement error correction and training effect evaluation; virtual reality technologies are mostly used for pre-competition simulated training. Overall, technologies cover the full training process yet are mostly applied independently with a low degree of integrated application.

3) PRACTICAL ACHIEVEMENTS OF EXISTING SMART TRAINING SCENARIOS

Smart training scenarios have been implemented in professional sports teams, sports universities and smart fitness venues across multiple regions in China, realizing visualized training data and dynamic training monitoring. Supported by intelligent training systems, certain ball games and track-and-field events have effectively improved training precision and reduced sports injury risks. Mass smart fitness scenarios enable intelligent recommendation of fitness plans and real-time recording of fitness data, greatly enhancing the scientificity of mass fitness.

B. EXISTING PROBLEMS OF SPORTS TRAINING EMPOWERED BY DIGITAL INTELLIGENT TECHNOLOGIES

1) SEVERE HOMOGENIZATION OF SCENARIO CONSTRUCTION AND INSUFFICIENT PERSONALIZED ADAPTATION

Training demands vary greatly across different sports events and training groups (professional athletes, teenagers, ordinary fitness enthusiasts). However, existing scenarios fail to adapt to individual differences and special demands of events, resulting in prominent homogenized construction that restricts the core advantages of intelligent training.

2) IMPERFECT DATA COLLECTION AND INTEGRATION SYSTEMS

Current data collection for smart training suffers from fragmentation and one-sidedness. Most equipment can only collect single-dimensional data, failing to realize linked collection of physical fitness data, technical movement data, psychological data and environmental data.

Meanwhile, inconsistent data ports of equipment from different brands and types hinder data integration and sharing, forming "data silos" that cannot provide complete data support for intelligent analysis.

3) INSUFFICIENT DEEP INTEGRATION OF TECHNOLOGIES AND SPORTS TRAINING SCENARIOS

Current technological applications mostly remain at superficial monitoring and data recording stages, while core

functions of intelligent analysis and intelligent decision-making are not fully implemented.

Most smart training scenarios merely realize "data visualization" without deeply mining training problems or dynamically optimizing training plans based on data.

Digital technologies only serve as auxiliary tools rather than being deeply integrated into training logic and processes, leaving the empowering value of technologies untapped.

4) LACK OF INDUSTRIAL STANDARDS AND NORMATIVE SYSTEMS

China's smart sports training industry has not formed unified construction standards, data standards and operation & maintenance standards. The absence of unified norms for scenario construction leads to uneven implementation quality; inconsistent standards for data collection, storage and transmission result in poor data compatibility; inadequate norms for scenario operation and services cause difficulties in long-term operation of some deployed smart training scenarios, leading to prominent resource waste.

5) INSUFFICIENT RESERVE OF INTERDISCIPLINARY COMPOUND TALENTS

The construction and operation of smart sports training scenarios require interdisciplinary talents with both professional sports knowledge and digital technology capabilities. Currently, sports professionals lack digital technology application skills, while information technology personnel are unfamiliar with sports training rules. The severe shortage of interdisciplinary compound talents greatly restricts the optimization, upgrading and innovative development of smart sports training scenarios.

IV. CONSTRUCTION OF SMART SPORTS TRAINING SCENARIO SYSTEM DRIVEN BY DIGITAL INTELLIGENT TECHNOLOGIES

A. GENERAL PRINCIPLES AND OBJECTIVES OF SCENARIO CONSTRUCTION

1) CONSTRUCTION PRINCIPLES

Scientific Principle: Based on scientific sports training theories and data mining theories, it follows sports training rules to ensure scientificity in scenario architecture design, data collection and intelligent analysis, fitting the training demands of different events.

Practical Principle: Focus on pain points of traditional training and practical application demands, simplify operation procedures, strengthen scenario implementability and operability, and balance construction costs and application benefits.

Innovative Principle: Leverage cutting-edge digital intelligent technologies to innovate training modes and application paths and break the homogenization limitations of traditional scenarios.

Adaptability Principle: Adapt to diverse scenarios including competitive sports, campus teaching and mass fitness, as well as training groups of different ages and proficiency levels to realize personalized adaptation.

2) GENERAL CONSTRUCTION OBJECTIVES

This paper aims to construct a smart sports training scenario system featuring "comprehensive data, intelligent analysis, diversified scenarios and long-term operation". It resolves pain points of homogenized, imprecise and unscientific traditional training, realizing full-process digital monitoring of training, personalized customized training plans and scientific evaluation of training effects. It promotes the transformation of sports training from empiricism to datamation, intelligence and precision, and provides scenario support for improving competitive sports performance, empowering national fitness and upgrading integrated sports and education development.

B. OVERALL ARCHITECTURE DESIGN OF SMART SPORTS TRAINING SCENARIOS

Combining the digital intelligent technology system and sports training demands, this paper constructs a four-tier progressive architecture for smart training scenarios with clear functional collaboration across tiers, forming a complete closed-loop intelligent training system, as shown in Table 1.

1) ARCHITECTURE DESIGN OF PERCEPTION & COLLECTION TIER

As the data foundation of the smart training system, the perception & collection tier collects high-precision and uninterrupted multi-dimensional data on athletes' physical fitness, movement posture, training loads and venue environments via intelligent wearable devices, motion capture terminals and venue monitoring equipment throughout training, providing raw support for back-end data analysis.

2) ARCHITECTURE DESIGN OF DATA PROCESSING TIER

The data processing tier integrates fragmented data collected from front-end terminals. It eliminates invalid abnormal data through cleaning, classified fusion and standard unification, resolves issues of scattered traditional training data and data silos, and builds a standardized training database to guarantee data validity and availability.

3) ARCHITECTURE DESIGN OF INTELLIGENT ANALYSIS TIER

As the core empowering link of the entire system, the intelligent analysis tier builds special analysis models based on artificial intelligence and data mining algorithms. It automatically identifies movement errors, evaluates training loads, predicts sports risks, and generates personalized optimization plans combined with individual training data, realizing the transformation from experiential training to data-driven intelligent decision-making.

TABLE 1. Overall Technical Architecture System of Smart Sports Training Scenarios

Architecture Tier	Core Components	Core Functions	Key Technical Support
Perception & Collection Tier	Intelligent wearable devices, motion capture terminals, environmental monitoring equipment	Collect multi-dimensional raw data including physical fitness, movements, loads and environments throughout training	Internet of Things, intelligent perception technology
Data Processing Tier	Data cleaning module, data storage module, data fusion module	Sort fragmented data, unify data standards and eliminate data silos	Big data, cloud computing technology
Intelligent Analysis Tier	Movement analysis module, load evaluation module, risk prediction module	Intelligently analyze training problems, evaluate training effects and generate optimization suggestions	Artificial intelligence, data mining technology
Scenario Application Tier	Various sub-smart training scenarios, terminal application platforms	Implement intelligent training services and realize personalized training and dynamic optimization	Digital twin, edge computing technology

4) ARCHITECTURE DESIGN OF SCENARIO APPLICATION TIER

The scenario application tier serves as the terminal for technological implementation and service delivery. Based on front-end data collection and intelligent analysis results, it provides differentiated intelligent training services for professional athletes, teenage students and mass fitness enthusiasts, supporting coaches to dynamically adjust training plans and deliver practical intelligent training outcomes.

C. SUB-CONSTRUCTION OF MULTI-DIMENSIONAL SMART SPORTS TRAINING SCENARIOS

Combined with different training subjects and demands, this paper subdivides five major smart sports training scenarios covering the full spectrum of competitive, campus and mass sports to achieve precise scenario adaptation, as shown in Table 2.

1) INTELLIGENT BASIC PHYSICAL FITNESS TRAINING SCENARIO

Targeting all-age groups, this scenario captures various physical fitness data via intelligent monitoring equipment to accurately identify individual physical fitness weaknesses. It generates personalized fitness improvement plans aligned with users'training goals and dynamically regulates training loads to effectively resolve imbalanced training intensity and realize scientific and precise improvement of basic physical fitness.

2) PRECISE SPECIAL TECHNICAL TRAINING SCENARIO

Primarily serving professional athletes and sports specialty students, this scenario disassembles special technical movements via motion capture and intelligent analysis technologies, accurately identifying movement deviations and force defects while providing real-time error correction guidance.

It optimizes technical details against standard movement models to realize refined training and iterative improvement of special techniques.

3) INTELLIGENT SPORTS INJURY PREVENTION & CONTROL TRAINING SCENARIO

Aimed at high-intensity training groups and teenagers, this scenario monitors training loads, body postures and sports status in real time. It identifies hidden injury hazards via AI risk prediction models and issues timely early warnings, dynamically adjusts training intensity and provides intelligent rehabilitation guidance to build an integrated safe training system covering training, prevention & control and rehabilitation.

4) PRE-COMPETITION SIMULATED TRAINING SCENARIO

Supported by digital twin and virtual reality technologies, this scenario reproduces real competition venues, rules and opponent characteristics to provide athletes with immersive simulated confrontation training. It optimizes tactical plans based on pre-competition training data to help athletes adapt to competition rhythms and boost on-site adaptability and competitive performance.

5) MASS SCIENTIFIC FITNESS TRAINING SCENARIO

For ordinary fitness practitioners, this scenario simplifies intelligent operation processes, matches lightweight fitness plans according to users' physical data and fitness demands, records fitness data in real time to generate phased analysis reports, and popularizes scientific fitness knowledge. It addresses blind fitness among the public and facilitates the scientific development of national fitness.

D. CONSTRUCTION OF SCENARIO OPERATION GUARANTEE MECHANISMS

1) DATA SECURITY GUARANTEE MECHANISM

Build a multi-layer data security protection system to encrypt storage and transmission of private information including trainees'physical data and training data, set hierarchical access permissions to prevent data leakage and abuse. Meanwhile, establish regular data backup and risk monitoring mechanisms to guarantee stable and secure training data and provide data security support for long-term scenario operation.

2) TECHNOLOGICAL ITERATION & UPDATE MECHANISM

Establish a dynamic technological iteration mechanism to keep pace with the development trend of digital intelligent technologies, regularly update scenario algorithm models, hardware equipment and functional modules. Continuously optimize technological application modes aligned with new industrial demands and scenario requirements of sports

TABLE 2. Multi-dimensional Sub-smart Sports Training Scenarios and Functional Adaptation

Sub-scenario Type	Target Groups	Core Training Functions
Intelligent Basic Physical Fitness Training Scenario	All-age training groups	Real-time monitoring of physical fitness data, analysis of physical fitness weaknesses, push of personalized fitness improvement plans, intelligent regulation of training loads
Precise Special Technical Training Scenario	Professional athletes, sports specialty students	Special motion capture, intelligent error correction of movements, iterative optimization of technical movements, quantitative evaluation of special training effects
Intelligent Sports Injury Prevention & Control Training Scenario	High-intensity training groups, teenagers	Real-time prediction of training risks, early warning of hidden injury hazards, intelligent guidance on rehabilitation training, dynamic adjustment of training intensity
Pre-competition Simulated Training Scenario	Participating athletes, sports teams	Virtual reproduction of competition scenarios, immersive simulated confrontation, data analysis of pre-competition status, intelligent optimization of competition tactics
Mass Scientific Fitness Training Scenario	Ordinary fitness practitioners	Intelligent matching of fitness demands, push of lightweight fitness plans, recording and analysis of fitness data, popularization of scientific fitness knowledge

training to maintain the technological advancement and functional adaptability of smart training scenarios.

3) DYNAMIC SCENARIO OPTIMIZATION MECHANISM

Build a feedback mechanism for scenario operation data, continuously collect user feedback and operational data during scenario application, analyze functional shortcomings and adaptation problems of scenarios, and targetedly optimize scenario architectures, functional modules and service modes to realize dynamic upgrading and continuous optimization of scenarios and improve scenario application quality.

V. APPLICATION INNOVATION AND EMPIRICAL ANALYSIS OF SMART SPORTS TRAINING SCENARIOS

A. INNOVATIVE APPLICATION DIRECTIONS OF SMART SPORTS TRAINING SCENARIOS

1) INNOVATION IN PERSONALIZED CUSTOMIZATION OF TRAINING PLANS

Breaking the traditional unified training model, big data and AI algorithms generate fully personalized training plans based on individual physical data, sports foundations, training goals and weak points. The system dynamically adjusts training content, intensity and duration according to daily physical status, completely resolving homogenization and poor adaptability of traditional training and realizing precise training.

2) INNOVATION IN DYNAMIC MONITORING AND EVALUATION OF TRAINING PROCESSES

It transforms the traditional mode of terminal and subjective evaluation to realize full-process dynamic monitoring and real-time evaluation of training. Intelligent equipment captures training data in real time, and AI systems automatically complete quantitative analysis of training effects, generating real-time evaluation reports and phased summaries. Training effects become quantifiable and training problems traceable, enabling refined management of the entire training process.

3) INNOVATION IN INTEGRATED INTELLIGENCE EMPOWERMENT OF TRAINING AND COMPETITION

Build an intelligent linkage system between training and competitions. Digital twin simulation technologies support pre-competition simulated training, while linked data analysis identifies correlations between training status and competition performance. Training data is used to optimize competition tactics and participation plans, realizing integrated training-competition empowerment of "preparing for competitions via training and boosting training via competitions" and enhancing the practical value of competitive training.

4) DIGITAL INNOVATIVE APPLICATION OF INTEGRATED SPORTS AND EDUCATION

Integrate smart training scenarios into campus physical education teaching and after-school training. Aligned with teenagers'growth and development rules and physical education syllabus, it intelligently generates campus physical education teaching plans and after-school training programs, realizing standardized classroom teaching and personalized after-school training. It facilitates the scientific development of campus sports and promotes the digital upgrading of integrated sports and education.

B. EMPIRICAL ANALYSIS OF APPLICATION EFFECTS

To verify the application value of smart sports training scenarios, this paper selects two track-and-field training teams from a sports university as research objects, setting an experimental group adopting smart training scenarios and a control group following traditional training modes for a 3-month comparative experiment. Application effects are verified from three dimensions: training efficiency, training precision and athletic ability improvement.

Variables are strictly controlled in the empirical experiment to ensure no significant differences in basic conditions between the two groups. Basic experimental information and grouping details are shown in Table 3.

1) ANALYSIS OF TRAINING EFFICIENCY IMPROVEMENT EFFECTS

After the training cycle, core indicators including average time spent correcting training problems and proportion of ineffective training hours are counted to compare training efficiency differences between the two groups, as shown in Table 4.

TABLE 3. Basic Information of Empirical Experimental Samples and Grouping

Sample Group	Size	Training Cycle	Training Mode	Training Content
Experimental Group	20	3 months	Intelligent training via smart scenarios	Track-and-field special techniques + basic physical fitness training (intelligent plans, dynamic monitoring)
Control Group	20	3 months	Traditional experience-based training	Track-and-field special techniques + basic physical fitness training (unified plans, manual monitoring)

TABLE 4. Comparison of Training Efficiency Indicators Between Two Groups

Group	Average Single Problem Correction Duration	Proportion of Ineffective Training Hours	Training Efficiency
Experimental Group	2.1 min	8.3%	91.7%
Control Group	5.8 min	22.6%	77.4%

The data indicates that smart training scenarios can rapidly identify training problems and provide error correction guidance, greatly shortening correction time and reducing ineffective training behaviors such as blind and overtraining. Training efficiency rises by 14.3%, significantly boosting the overall efficiency of sports training.

2) ANALYSIS OF TRAINING PRECISION OPTIMIZATION EFFECTS

To further quantify differences in training precision between the two groups, two core indicators — compliance rate of standardized special movements and compliance rate of matched training loads — are statistically analyzed, with comparative data shown in Table 5.

TABLE 5. Comparison of Training Precision Indicators Between Two Groups

Group	Compliance Rate of Standardized Special Movements	Compliance Rate of Matched Training Loads
Experimental Group	94.2%	92.6%
Control Group	78.5%	75.3%

The table reveals that the experimental group achieves far higher compliance rates of standardized special movements and matched training loads than the control group.

Supported by AI real-time motion analysis and dynamic load monitoring technologies, smart training scenarios precisely control training details and intensity, timely correct non-standard movements and adjust unreasonable training loads. They effectively resolve movement deviations and load imbalance in traditional training, greatly improving the precision and scientificity of sports training.

3) IMPROVEMENT EFFECTS OF ATHLETES' PHYSICAL FITNESS AND TECHNICAL CAPABILITIES

Comparisons of physical fitness indicators (endurance, explosive power) and special technical performance before and after the experiment show that the experimental group achieves greater improvement in physical fitness and a higher pass rate of special technical progress than the control group.

Personalized smart training plans can precisely address individual weaknesses and targetedly boost special capabilities to maximize training effects.

4) SUMMARY OF SCENARIO APPLICATION ADVANTAGES AND EXISTING SHORTCOMINGS

Empirical results prove that smart sports training scenarios feature core strengths including high precision, higher efficiency, strong adaptability and controllable risks, which can effectively make up for deficiencies of traditional training modes. Meanwhile, certain shortcomings remain: first, scenarios rely heavily on hardware equipment with high construction costs, hindering full popularization; second, special algorithm models for niche sports events are incomplete with room for improved adaptability.

VI. OPTIMIZATION STRATEGIES AND FUTURE DEVELOPMENT PROSPECTS OF SMART SPORTS TRAINING SCENARIOS

A. OPTIMIZATION AND UPGRADING STRATEGIES FOR SMART SPORTS TRAINING SCENARIOS

1) IMPROVE THE STANDARDIZED CONSTRUCTION SYSTEM OF SCENARIOS

Competent industrial authorities, sports universities, technology enterprises and professional sports teams shall jointly formulate unified standards for the construction, data collection, equipment adaptation, operation and maintenance services of smart sports training scenarios. Standardize scenario construction processes and implementation requirements to resolve current homogenization and uneven implementation quality, and promote standardized development of smart training scenarios.

2) DEEPEN INTEGRATED APPLICATION OF DIGITAL INTELLIGENT TECHNOLOGIES IN SCENARIOS

Break the limitation of shallow independent application of single technologies, promote integrated empowerment of IoT, big data, AI and digital twin technologies, and optimize intelligent analysis algorithm models to iterate special training models for different sports events and groups. Strengthen core functions of intelligent decision-making and optimization, integrate digital technologies deeply into the full training process and fully release technological empowering value.

3) BUILD AN INDUSTRY-UNIVERSITY-RESEARCH COLLABORATIVE INNOVATION DEVELOPMENT MODEL

Establish collaborative innovation platforms integrating sports universities, research institutions, technology enterprises and sports training entities.

Research institutions conduct theoretical research and algorithm optimization; technology enterprises develop scenarios and iterate equipment; training units carry out practical testing and feedback optimization.

Form a closed-loop mechanism of "research-deployment-implementation-optimization" to accelerate innovative implementation of smart training scenarios.

4) STRENGTHEN CULTIVATION OF INTERDISCIPLINARY COMPOUND TALENTS

Universities shall optimize training programs for sports majors, add courses covering digital sports and intelligent technology application, and cultivate interdisciplinary talents equipped with both professional sports capabilities and digital technology skills. The industry shall launch special training programs for in-service coaches and operation & maintenance personnel to improve their capabilities in intelligent equipment operation, data interpretation and scenario application, bridging the talent gap of the industry.

5) IMPROVE DATA SECURITY AND OPERATION & MAINTENANCE MANAGEMENT SYSTEMS

Perfect the data security management system for smart training, strengthen the application of data encryption, authority management and risk prevention technologies to guarantee users'data privacy and security. Establish regular scenario operation & maintenance mechanisms including periodic equipment inspection, system upgrading and functional optimization to ensure long-term stable operation of smart training scenarios.

B. DEVELOPMENT TRENDS AND RESEARCH PROSPECTS

With continuous iteration of digital intelligent technologies, the smart sports training industry will present trends of full-domain simulation, intelligent self-adaptation and universal application.

In the future, digital twin and virtual reality technologies will enable high-precision digital reproduction of sports training and competition scenarios, building an immersive training ecosystem integrating virtual and physical elements that significantly improves the scientificity of pre-competition simulation and special training.

Meanwhile, continuous optimization of artificial intelligence algorithms will gradually form self-adaptive training systems, where the system independently iterates training plans based on individual training differences, realizing an upgrade from passive data monitoring to active intelligent decision-making.

In addition, as scenario construction costs decline and technical thresholds lower, smart training models will gradually expand from competitive sports to campus sports and mass fitness fields, constructing a full-coverage intelligent smart sports ecosystem that continuously facilitates the digital and high-quality development of sports training.

REFERENCES

[1] T. Zhou, C. Hu, D. Liu, et al., "Digital twins and artificial intelligence for predictive maintenance in microelectromechanical systems (MEMS)," Microsyst. Technol., vol. 32, no. 8, p. 111, 2026, DOI: 10.1007/S00542-026-06081-6.

[2] R. Geng and T. Jin, "From 'Basic Framework' to 'Higher Level': Logical mechanism and adjustment path of China's national fitness policy evolution," Sport Sci., vol. 46, no. 2, pp. 91–101, 2025, DOI: 10.13598/j.issn1004-4590.2025.02.010.

[3] Y. Liu, "The Practice of Empowering Physical Education and Training in Colleges and Universities with Digital and Intelligent Technologies," Contemp. Educ. Front., vol. 3, no. 8, pp. 30–35, 2025, DOI: 10.18063/CEF.V3I8.876.

[4] Z. Hao, P. K. Malarvizhi, D. R. S. Jackson, "Internet of Things Framework in Athletics Physical Teaching System and Health Monitoring," Int. J. Artif. Intell. Tools, vol. 30, no. 8, 2021, DOI: 10.1142/S0218213021400169.

[5] M. B. R. Ţoniş, L. Vasile, A. Truşcă, et al., "Harnessing Artificial Intelligence in Sports Training: Evidence from Romanian Professionals Using SEM Analysis," Appl. Sci., vol. 15, no. 16, p. 8853, 2025, DOI: 10.3390/APP15168853.

[6] G. Tenenbaum, B. T. Zion, A. Y. Hamburger, et al., "Smart Sport Watch Usage: The Dominant Role of Technology Readiness over Exercise Motivation and Sensation Seeking," Technologies, vol. 13, no. 1, p. 24, 2025, DOI: 10.3390/TECHNOLOGIES13010024.

[7] C. Junfei and Z. Bosi, "Development Trend of Digital Physical Education Teaching by Integrating Intelligent Sensor Technology," Secur. Commun. Netw., 2022, DOI: 10.1155/2022/3039349.

[8] X. Liu, R. Wang, Z. Qin, "Guiding role of infrared thermal radiation images based on sensors in sports training: Application of artificial intelligence," Therm. Sci. Eng. Prog., vol. 58, p. 103208, 2025, DOI: 10.1016/J.TSEP.2024.103208.

[9] L. Zhang and G. Liu, "Digital Transformation in Physical Education: The Application of Intelligent Technology in Enhancing the Effectiveness of Sports Teaching," J. Electr. Syst., vol. 20, no. 2, pp. 1385–1391, 2024, DOI: 10.52783/jes.1365.

[10] B. Mai, L. Xie, P. Ning, "Harnessing Big Data for Smarter Physical Education: A Quasi-Experimental Study on Real-Time Analytics and Adaptive Coaching," Int. J. Hum.–Comput. Interact., vol. 42, no. 12, pp. 9387–9410, 2026, DOI: 10.1080/10447318.2025.2576637.

[11] X. Yan, "Design and Practice of Sports Training Simulation System Based on Virtual Reality Technology," Int. J. Hous. Sci. Appl., vol. 46, no. 4, p. 499, 2025, DOI: 0.70517/ijhsa46445.

[12] Z. S. Zhang, Z. H. Yang, Y. Gao, "IoT framework for sports activity safety monitoring based on wearable sensors and CRNN spatiotemporal analysis," Sci. Rep., vol. 16, no. 1, p. 11441, 2026, DOI: 10.1038/S41598-026-41195-X.

[13] Y. Liu, X. Liu, H. Ni, et al., "Industrial IoT-Oriented Motion Analysis Based on Binocular Vision and Eye-Tracking for Sports Scenarios," Internet Technol. Lett., vol. 9, no. 1, p. e70187, 2025, DOI: 10.1002/ITL2.70187.

[14] M. Y. He and D. W. Luo, "Research on Sports Data Mining and Sports Training Decision Support System Based on Big Data Technology," Int. J. High Speed Electron. Syst., vol. 34, no. 1, 2024, DOI: 1142/S0129156425401330.

[15] I. N. A. Atifah, "Implementation of AI technology in sports development: A literature review," BIO Web Conf., vol. 21, p. 01002, 2026, DOI: 10.1051/BIOCONF/202621701002.

[16] C. Rong and F. Tian, "Research on the New Mode of Integration and Development of College Students' Physical Education Teaching and Athletic Training Empowered by Cloud Computing Technology," Appl. Math. Nonlinear Sci., vol. 10, no. 1, p. 20251088, 2025, DOI: 10.2478/AMNS-2025-1088.