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Article

Evaluation of sports fitness and biomechanics health monitoring for the integration of blockchain and internet of things

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Abstract: As the economy grows and living standards improve, there is an increasing awareness of the importance of health. Traditional sports monitoring tools often fall short in terms of functionality, accuracy, and efficiency, especially when it comes to biomechanical analysis. This study investigates the integration of blockchain and Internet of Things (IoT) technologies in health monitoring within the biomechanics field, involving 300 students, 100 teachers, and 300 other participants. The participants were divided into an experimental group that utilized blockchain-IoT monitoring and a control group that relied on traditional methods. By employing the Byzantine consensus mechanism, data were analyzed in terms of processing efficiency, accuracy, effectiveness, and achievement of biomechanical fitness standards. The results indicated that the experimental group achieved higher rates of meeting weight standards (with an average of 82%) compared to the control group (76%). These findings underscore the potential of blockchain-IoT integration in enhancing the accuracy and effectiveness of biomechanical monitoring. This technology can promote a deeper understanding of biomechanical principles and improve nationwide fitness and exercise engagement by providing more reliable and precise data on physical performance and movement patterns.

Keywords: biomechanical health monitoring; blockchain technology; internet of things; physical fitness

1. Introduction

With the improvement of people's living standards, the demand for healthy physical fitness has been increasing. Traditional health monitoring systems show a declining trend in the country's overall health, primarily manifested in the gradual rise in obesity rates, as well as decreases in vital capacity, endurance, speed, and explosive power. The ability to regulate physiological functions such as blood pressure and blood sugar is also deteriorating. To address these issues, this paper proposes a health monitoring mechanism that integrates blockchain and the Internet of Things, aiming to improve the quality of monitoring and establish a scientific, comprehensive physical fitness monitoring system. Blockchain technology, as a distributed database technology, allows health monitoring data to be stored across multiple nodes, with each node holding a complete copy of the recorded data. This ensures that data sharing and circulation are secure and tamper-proof. In sports health monitoring, blockchain can achieve digital credentials, hosting systems, and trust mechanisms, making health monitoring data more reliable and secure, thus providing a strong technological foundation for improving national physical fitness and health management.

With economic development and improved living standards, public health awareness has been continuously rising, making national-level health monitoring increasingly important. Effective health intervention management is crucial for improving the overall health of the population. Scholars both domestically and internationally have conducted extensive research on exercise health and monitoring methods. Tasoglu [1] believed that regular health monitoring could detect diseases early, provide timely medical services, and greatly improve patient outcomes. Verma Prabal proposed that IoT technology provides an efficient and structured method for mobile health and remote patient monitoring, but delays caused by cloud data transfer in real-time applications can affect effectiveness. He suggested using fog computing to enhance the timeliness of health monitoring [2]. Verboven and Dominique [3] emphasized that exercise intervention is essential in treating adult obesity, significantly improving cardiovascular and metabolic risk factors. However, existing research primarily focuses on exercise interventions and health monitoring methods, lacking deeper technical exploration. In recent years, the integration of blockchain technology and the Internet of Things has provided new solutions for exercise health monitoring, effectively improving data accuracy and monitoring efficiency [4].

In this context, many scholars have started to explore the application of blockchain and IoT in sports health. Wilkerson et al. [5] believed that combining IoT technology with analytical methods could enhance athlete safety by identifying injury risk factors and improve the quantification of functional abilities. Wang and Gao [6] pointed out that the rapid development of smartphone IoT technology provides an effective way to monitor real-time health data, offering an alternative to traditional health monitoring methods. Elumalai and Ramakrishnan [7] argued that continuous monitoring of physiological parameters based on blockchain platforms is crucial for improving athletes' performance. Huynh-The Thien proposed that IoT technology, through wearable sensors for body activity recognition, not only improves the quality of life in smart cities but also enables early detection of unhealthy behaviors and potential health risks [8]. Although these studies have made progress at the theoretical level, further in-depth exploration in real-world applications is needed.

With the rapid development of the economy and the improvement of living standards, health management and monitoring have become a global focus. However, traditional health monitoring methods have numerous shortcomings in terms of functionality, accuracy, and efficiency, making it difficult to meet the growing demand for health services. In recent years, the integration of blockchain technology and the Internet of Things (IoT) has provided new solutions to address these issues. Shaikh et al. [9] proposed a UAV-assisted Stackelberg game model to secure IoT healthcare networks, especially in the application of remote medical monitoring, demonstrating how innovative mechanisms can enhance network security and data integrity. Additionally, Shaikh et al. [10] also developed an anomaly-based intrusion detection system, RCLNet, which effectively protects the security of the Internet of Medical Things (IoMT), ensuring the accurate transmission and privacy protection of health data. These studies provide the theoretical foundation and technical support for this research, confirming the importance of blockchain and IoT in enhancing health monitoring efficiency and data security. This study aims to further explore the application of blockchain and IoT technologies in sports health monitoring, assessing their potential in improving monitoring accuracy, enhancing efficiency, and promoting nationwide fitness engagement.

To address the inefficiency and inaccuracy of traditional sports health monitoring, this study designed a new health monitoring model combining blockchain and IoT technologies, aiming to improve monitoring efficiency and data accuracy. Experimental results demonstrated that this model significantly enhanced the effectiveness of health monitoring, reduced data errors, and outperformed traditional methods in multiple key indicators. This research shows that the integration of blockchain and IoT can effectively improve the accuracy and effectiveness of sports health monitoring, providing new technological support for nationwide fitness and exercise management.

2. Application methods for the integration of blockchain and the internet of things

2.1. Application of the internet of things in sports physical health monitoring

2.1.1. Definition of the internet of things

The Internet of Things is the real-time collection of any object or process that needs to be monitored, connected, or interacted with through various information sensing devices, such as the application of smart homes in daily life [11,12]. With the development of technology, various technological products such as refrigerators, air conditioners, and washing machines have stood out, providing people with advanced functions that traditional products cannot provide, and bringing great convenience to people’s lives. Intelligent transportation is gradually not as eye-catching as people’s eyes. Traditional transportation software plays a navigation role, while intelligent transportation uses information technology to closely integrate people, vehicles, and roads, collecting and analyzing information such as the number of vehicles, road usage rate, driving distance, driving time, and driving speed, providing people with a good driving environment and experience, and providing real-time traffic data to ensure safe driving. The Internet of Things is a huge industry with enormous development potential, and it would also bring a new era.

2.1.2. Research on the application of internet of things in sports physical health monitoring

According to the definition of the Internet of Things mentioned above, the combination of Internet of Things technology and sports monitoring would greatly promote the development of sports. Sports come in various forms. Regardless of the form of exercise, the purpose is to enable athletes to fully unleash their sports potential, stimulate their interest in sports, and comprehensively improve their physical and mental health development. It is precisely because of this trait that the physiological data of athletes needs to be monitored. Due to the wide variety of sports physiological data and the high requirements for professional quality in physiological data analysis, it is believed that recording and analyzing data is time-consuming, difficult, and inefficient. The emergence of IoT technology for motion detection has brought great help to people. The combination of Internet of Things technology and sports monitoring data can provide real-time physical index data of athletes, and provide guiding suggestions for healthy exercise of athletes.

2.2. Application of blockchain technology in sports physical health monitoring

2.2.1. The characteristics of blockchain technology

Firstly, with a decentralized structure, blockchain utilizes distributed recording and storage to process received data, eliminating the possibility of centralized processing or management of data. Data distribution processing improves data analysis efficiency, and saves time and costs. The second is openness, where blockchain data can be used and queried by users anytime and anywhere, without being limited by time, space, or nodes. This provides convenience for users and makes data sharing possible. Thirdly, autonomy refers to the standardization of the usage of blockchain users for all users. Users must operate and execute according to the prescribed protocols, and the highly autonomous nature maintains the network environment. Fourthly, information cannot be tampered with. After blockchain information is uploaded, users cannot make personal changes to the data. This also prevents users from entering data incorrectly or losing data due to accidental deletion, ensuring the reliability and security of the data. The fifth is anonymity. The blockchain protects users' personal information from being disclosed or made public. Users can freely share information in the online world. Other users can only see the shared information resources and cannot know the information provider or information source [13,14].

2.2.2. Overall system structure

In the blockchain and Internet of Things (IoT) integrated sports health monitoring system, the overall architectural design is key to realizing the system's functionality. By leveraging the distributed ledger technology of blockchain and the efficient data collection capabilities of IoT, the system achieves real-time monitoring, precise analysis, and secure transmission of athletes' health data. Sensors, as the core components, are responsible not only for collecting physiological data but also for transmitting it to user-end devices via Bluetooth modules while collaborating with the backend server to perform complex data analysis. To present the system architecture and workflow more intuitively, **Figure 1** illustrates the overall structure of the system.

As shown in **Figure 1**, the system architecture primarily consists of four main components: The sensor module, Bluetooth communication module, backend server, and user terminal. The sensor module collects health data such as heart rate, respiratory rate, and blood pressure by monitoring users' physiological indicators. The collected data is transmitted in real-time to the backend server via the Bluetooth communication module. The server conducts in-depth analysis using built-in algorithms and sends the analysis results back to the user terminal through the same Bluetooth connection. The user terminal not only allows users to view health data in real-time but also maintains a stable connection with the detector, enabling users to check their health status anytime and anywhere. This integrated system architecture demonstrates a seamless flow of data collection, transmission, analysis, and feedback, ensuring data security while enhancing the efficiency of health monitoring and user experience.

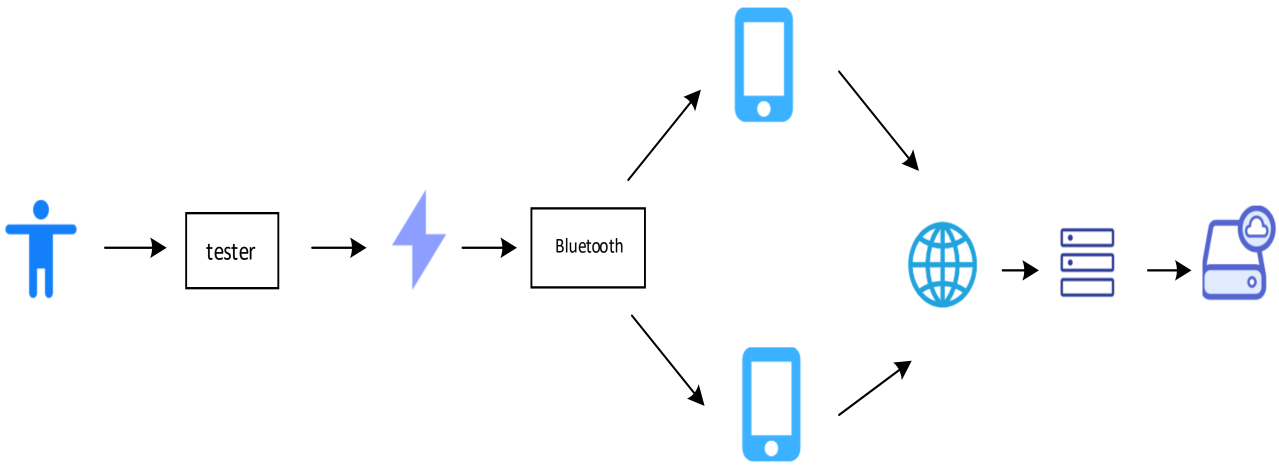


Figure 1. Overall system structure.

2.3. System software design and algorithm implementation

By integrating exercise methods, physical health monitoring, and the combination of blockchain and the Internet of Things, and utilizing the consensus mechanism of practical Byzantine algorithms in blockchain, a definition of sports physical health monitoring that integrates blockchain and the Internet of Things is proposed [15,16].

In the sports blockchain, the consensus mechanism collects monitoring data. Different categories of data are collected. In order to facilitate the identification of data, the information data elements are numbered and recorded as *s*, and each data element is expressed by an integer as $\{0, 1, 2, 3, \ldots 3a + 1\}$, which meets the following requirements:

$$\mathrm{R} = \mathrm{smod}\ 3\mathrm{a} + 1 \tag{1}$$

Among them, *s* represents consensus network initialization, and R represents motion blocks.

Blockchain information represents the integrated data; *A* represents the processing rate of storing blockchain data; *C* represents the time spent on motion monitoring data collection; *E* represents the data update rate; *F* represents the time spent on data, and the overall expression is:

$$\mathrm{DInfo} = (D_A, D_C, D_E, D_F) \tag{2}$$

The construction of a sports blockchain is conducive to simplifying the analysis steps of physical fitness monitoring data. Based on the sports blockchain, the collected sports monitoring data is classified and processed according to algorithms. Different types of information are stored on different nodes, and the stored information is run simultaneously through multiple programs. Finally, the analysis results of each type of data are sent to the blockchain network. The mapping form of blockchain network elements is:

$$\mathrm{Element}: Y_q \rightarrow Y_q^z \tag{3}$$

The data analysis results of the motion block link are achieved through the data integration program to achieve the sum of elements Y_q. The final display of data information is:

$$\mathrm{Data} = (\mathrm{process}, \mathrm{j}, \mathrm{k}, \mathrm{l}) \tag{4}$$

The probability of normal transmission of motion monitoring data in the network is θ; the probability of error in motion monitoring data collection is σ; the probability of error data affecting the entire monitoring data collection, processing, and transmission is σ_g:

$$\sigma_g \begin{Bmatrix} \left(\frac{\theta}{\sigma}\right)^g, \theta \leq \sigma \\ 1, \sigma \leq \theta \end{Bmatrix} \tag{5}$$

According to the rule of the number of blocks different between the error data and the normal data, it meets the probability density relationship of the Poisson distribution, with $\theta \leqslant \sigma$. The probability of success of the error data attack H is:

$$\mathrm{H} = \lim_{\gamma \to \infty} \sum_{a<k<\beta} \frac{e^{-\gamma}\gamma^k}{k!} \left(\frac{\theta}{\sigma}\right)^x, k = 0,1,2\ldots \tag{6}$$

In short, the practical Byzantine algorithm is one of the most widely used technological methods in blockchain technology, and has also played an important role in sports physical health monitoring. It can protect the safety of physical fitness measurement data for athletes, improve the efficiency and accuracy of health monitoring, promote the synergy and traceability of health monitoring, improve the quality of physical fitness testing, and solve the problems of low efficiency in traditional sports detection and inability to timely send monitoring data to users. It is of great significance for the development of physical fitness health monitoring in sports.

In the implementation of the blockchain and IoT integrated system, this study is based on the HyperFit blockchain platform, which uses Hyperledger Fabric as its core framework and integrates modular services specifically designed for sports health monitoring. For data collection, multifunctional sports sensors such as the FitSense Pro series are employed, capable of accurately measuring key indicators including heart rate, blood pressure, respiratory rate, and movement trajectory. These sensors communicate with user terminals in real-time via Bluetooth 5.0 modules. The user terminals run a custom-developed application, FitHealth App, which provides data visualization, displays analysis results, and pushes health recommendations.

The backend server utilizes AWS Lambda, a cloud computing service, to handle large volumes of data. Deep learning algorithms, developed using the TensorFlow framework, are implemented to enhance data analysis accuracy. To ensure the security and stability of data transmission, the system incorporates the Practical Byzantine Fault Tolerance (PBFT) algorithm and applies AES-256 encryption to protect monitoring data throughout the process. Different categories of health data are stored on distributed nodes within the blockchain network, with data analysis results processed in parallel across multiple programs and then synchronized back to the blockchain.

The coordinated operation of these devices and software not only achieves real-time and accurate health monitoring but also enhances the credibility of data through the immutability of blockchain technology, laying a solid foundation for building a new ecosystem for sports health monitoring.

3. Physical fitness and health monitoring experiment and evaluation

3.1. Experimental design

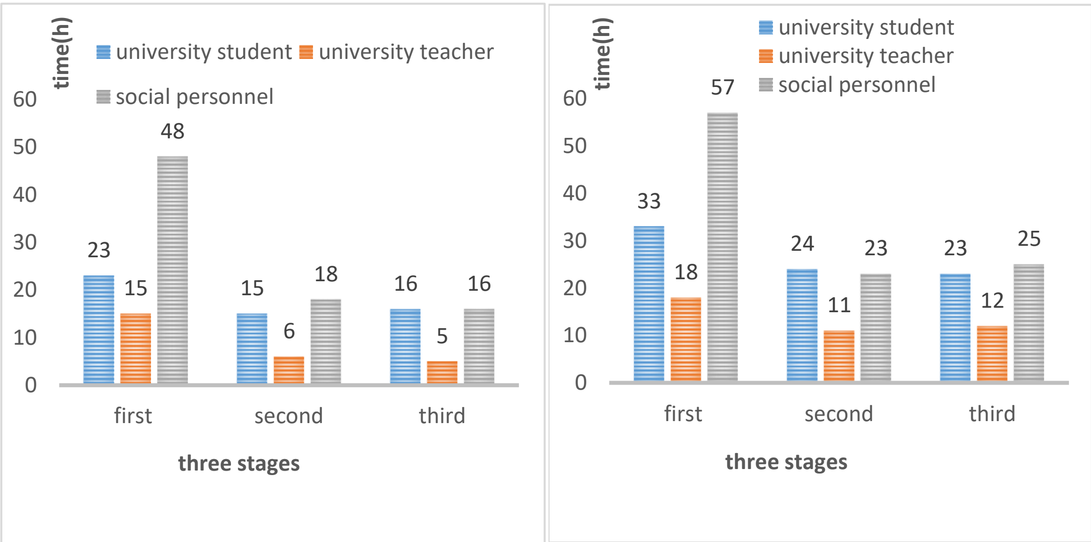
In the new stage of China's socio-economic development, the government is increasingly emphasizing the improvement of comprehensive physical fitness, promoting the development of national sports from various perspectives of social development. Whether it is the construction of sports infrastructure or the establishment of sports organizations guided by community sports, the state and government are actively promoting comprehensive sports, aiming to enhance the physical fitness of the people and promote the harmonious development of socialist society through comprehensive fitness and physical exercise. By utilizing information technology to achieve automation, intelligence, and efficiency in monitoring physical fitness and health, the level and efficiency of health monitoring can be improved; the risk of data errors can be reduced; the effectiveness of health monitoring can be improved. Blockchain and Internet of Things technologies, as important components of modern information technology, are playing an increasingly important role in monitoring physical fitness and health during exercise. Blockchain technology, through its characteristics of de autonomy and non tampering of information, can improve data security and reliability, effectively preventing tampering and forgery of physical fitness testing data. The Internet of Things can achieve elastic expansion and high availability of sports physical health monitoring, improving the efficiency and accuracy of sports physical health monitoring data. Therefore, this article aims to study the application of blockchain and Internet of Things technology in sports physical health monitoring, and explore how to use these two technologies to improve sports physical health monitoring and improve the level and efficiency of sports physical health monitoring.

Based on the above situation, this article randomly selected college students, university teachers, and social figures for investigation and research. Among them, 300 college students were tested; 100 testing teachers were tested; 300 other social personnel participated in the test, totaling 700. This article designed an experimental group (350 people) and a control group (350 people). The experimental group used blockchain and IoT technology to monitor physical fitness and health, while the control group used traditional physical fitness and health monitoring models.

This paper has implemented a series of measures to protect privacy and ensure the security and compliance of personal health data. Firstly, by integrating blockchain technology's decentralized and tamper-resistant features, the security of the data is guaranteed. All health data is encrypted for storage, and access is restricted to authorized users, preventing data breaches and misuse. Additionally, data collected by IoT devices is transmitted securely through encryption, ensuring data security during transmission and preventing interception or tampering. Secondly, smart contract technology is used to regulate data access and ensure that only authorized individuals can access sensitive information. Furthermore, this paper integrates strict data protection regulations in its practical application to ensure that all participants use health data within a legal framework, safeguarding privacy and reducing potential ethical risks.

3.2. Comparison and evaluation of physical fitness data processing efficiency

Physical fitness data processing refers to the time required to record, organize, and publish certain data during the physical fitness testing process. The higher the efficiency of physical fitness data processing, the lower the time required to complete data integration work, which means that universities and related parties can quickly obtain physical fitness testing data, timely understand the sports and physical fitness status of college students and others, and improve the overall health quality of the whole population. The efficiency of physical fitness data processing can be compared from the following three indicators, which are also the three stages of data processing. The first stage is the recording time of physical fitness data; the second stage is data processing and integration time; the third stage is data analysis and publication time. As shown in **Figure 2**, the comparison of physical fitness data processing efficiency is shown. **Figure 2a** shows the experimental group, and **Figure 2b** shows the control group.



(a) **(b)**

Figure 2. Comparison of physical fitness data processing efficiency, **(a)** efficiency of constitution data processing based on the integration of blockchain and the Internet of Things; **(b)** efficiency of physical fitness data processing under traditional methods.

It can be seen that under the physical fitness data processing mode of integrating blockchain and the Internet of Things, the first stage of college students' physical fitness data recording time was 23 h, which was a 30% reduction compared to traditional methods. This is mainly because the integration of blockchain and the

Internet of Things reduces the time and complexity of manual recording, and modern technology automatically records the physical fitness data of the measurer, improving the efficiency of data recording and avoiding time waste. In the second stage of data processing and integration, the total time spent by the three types of personnel using this method was reduced by 33% compared to the total time spent by the three types of personnel using traditional methods (the total time spent by the three types of personnel using this method was 39 h, while the total time spent by the three types of personnel using traditional methods was 58 h). In the third stage of data analysis and publication, the time used for college students, university teachers, and social personnel using this method was 16 h, 5 h, and 16 h, respectively, while in traditional methods, the corresponding time for the three was 23 h, 12 h, and 25 h. Obviously, the sports physical fitness and health monitoring mode that integrates blockchain and the Internet of Things can significantly shorten the data sorting time compared to traditional modes, thus achieving a significant improvement in data processing efficiency.

The improvement in data processing efficiency in the sports health monitoring model integrating blockchain and IoT can be attributed to the automation and decentralization features of the technology. First, blockchain technology ensures data security and immutability, while IoT technology enables real-time data collection and transmission through smart sensors, significantly reducing the time and complexity of manual recording. In traditional models, all data recording and processing require manual operation, which can lead to errors and delays, resulting in longer data processing times. In the experimental group, the blockchain-IoT-based model significantly reduced the recording time in the first stage, primarily due to the automated data collection, which avoided the time wastage and errors that could occur in manual recording. Additionally, the efficiency improvement in the data processing and integration stage is also due to the decentralized nature of blockchain technology, which allows data to be synchronized and integrated more quickly and accurately, avoiding the issues of data lag and redundant entry present in traditional methods. In the data analysis and publication stage, the integration of blockchain and IoT further improved the accuracy and timeliness of data analysis, enabling various personnel to obtain the required health data in a shorter time. The combined use of these technologies not only shortened the entire data processing time but also improved the accuracy and efficiency of data processing, resulting in better overall performance in the integrated blockchain-IoT model. In contrast, the traditional model, which relies on manual operation and inefficient technology, is unable to process such large and complex data sets in the same amount of time, leading to a significant decline in data processing efficiency.

3.3. Comparative evaluation of data accuracy

Data accuracy refers to the accuracy and reliability of physical fitness data in the process of monitoring physical fitness during exercise. In the combination of modern information technology in sports health and physical fitness monitoring, as the input and processing of data are completed in computer systems, it can greatly reduce the interference and error of human factors on the data, making it easier to ensure data accuracy than traditional methods. Data accuracy can be compared from the following three indicators. Error rate refers to the error rate in recording data entry, calculation, verification, and other processes. The processing miss rate refers to the proportion of unprocessed or missed data recorded in the total data volume. The accuracy rate of recorded data is the ratio of the number of accurate times of recorded data to the total number of times. **Table 1** focuses on the accuracy analysis of sports physical fitness and health monitoring data for the integration of blockchain and the Internet of Things, while **Table 2** presents the data accuracy analysis based on traditional models.

Table 1. Accuracy analysis of sports physical fitness and health monitoring data for the integration of blockchain and Internet of Things.

	error rate (%)	**handling misreporting rate (%)**	**record data accuracy rate (%)**
university student	0.3	0.2	99.7
university teacher	0.4	0.4	99.6
social personnel	0.2	0.3	99.8
average	0.3	0.3	99.7

Table 2. Data accuracy analysis based on traditional mode.

	error rate (%)	**handling misreporting rate (%)**	**record data accuracy rate (%)**
university student	1.5	2.1	98.5
university teacher	1.6	2.3	98.4
social personnel	1.6	2.2	98.4
average	1.57	2.2	98.43

Under the sports physical health monitoring mode that integrates blockchain and the Internet of Things, the average error rate was 0.3%; the average processing miss rate was 0.3%; the average data recording accuracy was 99.7%. In the traditional mode, the average error rate was 1.57%; the average processing miss rate was 2.2%; the average data recording accuracy was 98.43%. Compared to traditional monitoring modes, the sports physical fitness and health monitoring mode that integrates blockchain and the Internet of Things has significant advantages in indicators such as error rate, processing miss rate, and data recording accuracy, indicating that this mode can significantly improve data accuracy.

3.4. Comparison of effects between two modes

With the improvement of living standards, the physical condition of the Chinese people, especially students, is increasingly declining, and has now become a focus of attention for the whole society. In the monitoring of physical fitness in sports, there are problems such as insufficient monitoring efforts, incorrect recording of physical fitness data, or low efficiency in organizing physical fitness data. This article focuses on this issue and adopts a sports fitness and health monitoring mode that integrates blockchain and the Internet of Things. The test subjects are domestic college students, university teachers, and social figures. In order to test the effectiveness of the method used in this article, an online survey questionnaire method is used to collect the feelings of the test personnel towards the new mode of sports monitoring.

From **Figure 3**, it can be seen that 80% of the testers gave very effective suggestions for the method proposed in this article, with 10% considering it to be relatively effective, 7% considering it to be generally effective, and only 3% considering it to be ineffective. In traditional methods, the proportion of effectiveness was considered to be 50%, which was reduced by 30% compared to the method in this article. The proportion of effectiveness was considered to be 10%, which was no different from the method in this article. The proportion of effectiveness was generally considered to be 10%, and the proportion of ineffectiveness was considered to be 30%, which was 27% higher than the method in this article. Among them, most people believed that using the method presented in this article provided convenience for sports fitness monitoring. Traditional methods of data recording are mostly manual, time-consuming, labor-intensive, and inefficient, with a high error rate in data recording. The data entry method is single, and data integration takes a long time, making it difficult to provide timely feedback on physical fitness status. The method proposed in this article can bring good news for monitoring physical fitness and health during exercise, allowing users to check their exercise status anytime and anywhere, while also playing a supervisory role and timely reminding users to exercise regularly. From this, it can be seen that the mode adopted in this article provides great assistance to athletes.

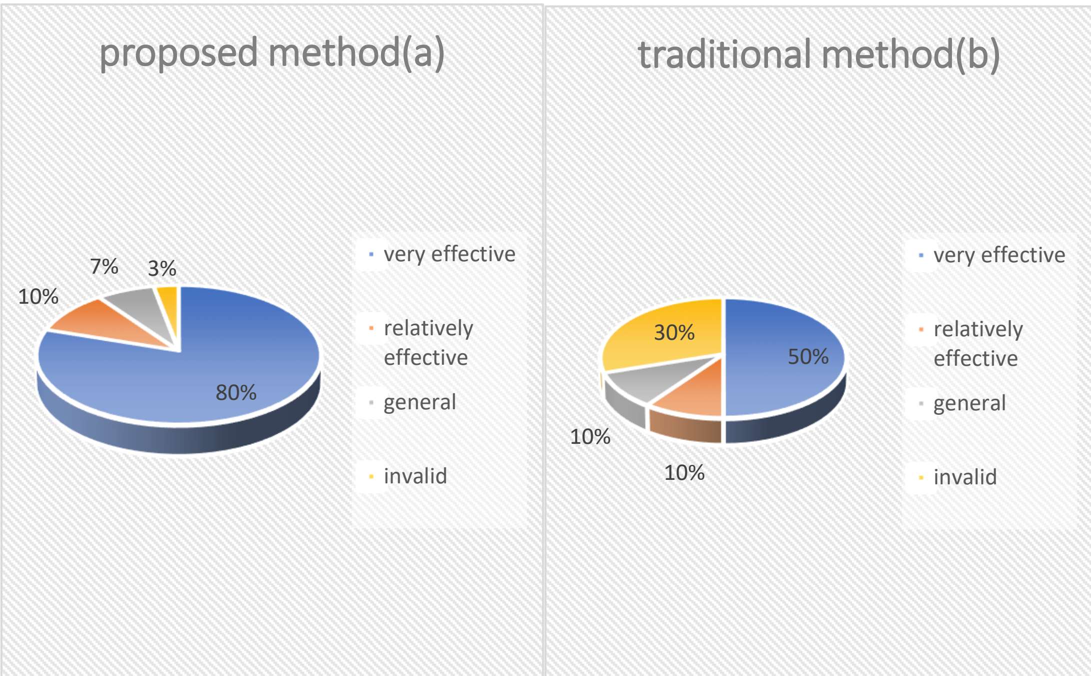


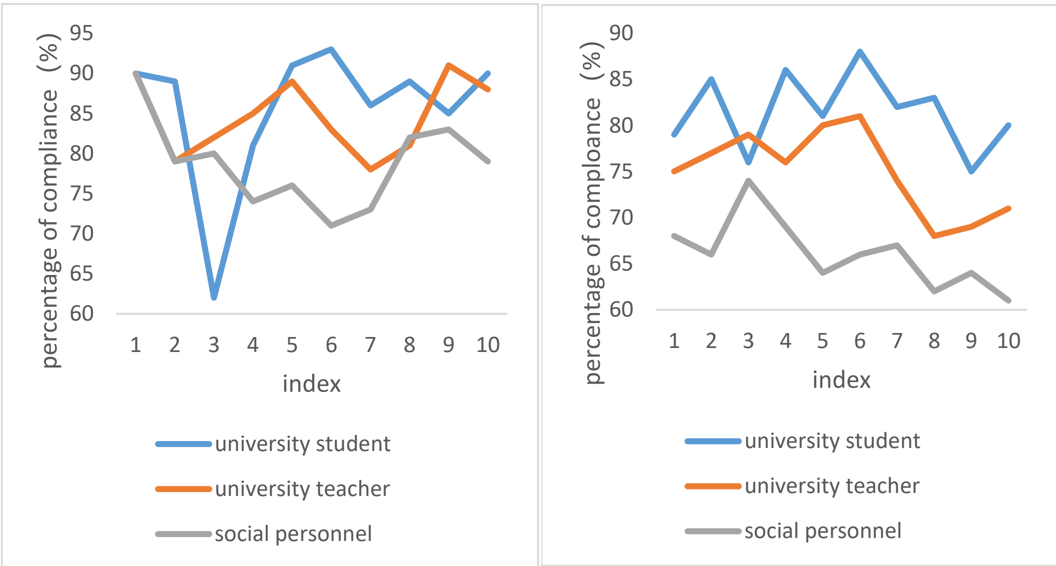
Figure 3. Comparison of effects between two modes, **(a)** the feedback of the effectiveness of the method in this article; **(b)** the feedback effect of traditional methods.

3.5. Comparison of the percentage of physical fitness standards between two groups of personnel

Body shape marks the development level of the human body's physique, body shape, body composition, and other aspects. It is an important aspect of measuring the quality of the human body's physique. By measuring height and body mass index, it can be determined whether the human body is within a healthy weight range and whether there are problems with body composition imbalance [17,18]. Physical function refers to the level of metabolism of the body and the efficiency of various organ systems, mainly reflecting the level of physiological function of the human body, including heart rate, vital capacity and blood pressure. Vital capacity can reflect the volume and expansion capacity of the lungs, which is the most intuitive and objective indicator for detecting lung function, and is also a common functional indicator for evaluating the growth and development level of the human body and the physical condition [19]. Quiet heart rate refers to the number of beats per minute in a calm state of wakefulness and inactivity. Blood pressure is an important indicator of vital signs in the human body. The level of blood pressure can help determine whether multiple indicators such as heart function, blood flow, blood volume, and vascular dilation and contraction function are properly coordinated [20]. Physical fitness is closely related to the body's athletic ability [21], and the main indicators that reflect the body's athletic ability and level include speed, endurance, agility, flexibility, and other indicators. In this study, the tests related to physical fitness mainly include five items: 1000 m (male), 800 m (female), push ups, sitting forward bending, and standing long jump. Endurance refers to the ability of the human body to engage in muscle activity for a long time [22]. The main purpose of endurance training is to develop aerobic metabolism ability and improve the function of the cardiovascular system. Endurance testing projects usually focus on long-distance running of 1000 m for males and 800 m for females. Long jump reflects the explosive strength of the human body; push ups reflect the static and dynamic strength of the human body; sitting forward bending mainly reflects the flexibility of the human body.

In this paper, people with roughly the same physical condition were randomly selected for a control experiment. The subjects were divided into two groups (150 university students, 50 university teachers and 150 social workers in each group). One group exercised according to the traditional mode, and the other group exercised using this mode. After a period of time, this paper compared the height, weight, long-distance running, sprint, vital capacity, heart rate, blood pressure, sitting three-dimensional flexion, push ups and standing long jump of the experimental group and the control group.

From **Figure 4**, it can be seen that overall, the physical condition of personnel using this method was better than that of personnel using traditional methods. Height was controlled by multiple factors and was greatly influenced by uncontrollable factors such as genes and age. Therefore, there is no statistically significant change in the height of experimental personnel before and after the experiment, and there is no comparison. Secondly, in terms of weight, there were significant differences among the experimental personnel before and after the implementation of the model in this article. The proportions of the three types of personnel who achieved weight standards using the method in this article were 89%, 79%, and 79%, respectively. The proportions of the control group personnel who achieved weight standards were 85%, 77%, and 66%, respectively. However, the average proportion of the experimental group who achieved body weight standards was 82%, while the average proportion of the control group who achieved weight standards was 76%. Whether it is a horizontal or vertical comparison, the effectiveness of using this method is higher than that of traditional methods. This also indicates that continuous and regular participation in physical exercise has a certain positive promoting effect on improving body shape. However, this system can monitor user health data in a timely manner, provide timely feedback on body change indicators, and provide users with the latest body dynamics information in real-time, encouraging users to actively participate in physical exercise. Thirdly, the statistical results show that the heart rate, vital capacity and blood pressure of the experimental group and the control group have obvious changes before and after the implementation of sports health physique monitoring. As far as the vital capacity index is concerned, the vital capacity of the experimental group accounted for 91%, 89% and 76% respectively, while the vital capacity of the control group accounted for 81%, 80% and 64% respectively. It is obvious that the vital capacity under this model shows a greater trend of increase. Fourthly, in terms of indicators such as long-distance running, sprinting, sitting forward bending, and push ups, the target achievement rate in this mode is higher than that in the traditional mode. In summary, the integration of blockchain and the Internet of Things in sports and physical health monitoring has achieved great results.



(a) **(b)**

Figure 4. Comparison of the percentage of people in two groups who meet the physical fitness standards, **(a)** the proportion of physical fitness standards in the model of this article; **(b)** the proportion of physical fitness standards in the traditional mode.

4. Conclusions

With the popularization of intelligent terminals and the increasing demand for daily fitness and exercise in modern society, traditional exercise monitoring models are no longer able to meet the needs of users. This article took the integration of blockchain and the Internet of Things for sports fitness and health monitoring as the analysis object, studied the architecture of the Internet of Things and blockchain software systems, and completed the design of a human sports health reference detection system. This system can measure the acceleration, heart rate, body temperature and other health data of human movement, and provide personalized health guidance suggestions by analyzing and judging the measured health data. The system testing results are good, and it can achieve relatively complete functions such as collecting, analyzing, and displaying human health information, improve the efficiency of data collection and analysis, and ensure the accuracy of data. Therefore, this mode is of great significance for athletes and is worth trying and promoting. Although blockchain and IoT technologies offer significant advantages in sports health monitoring, they still face some challenges. First, the implementation cost of these technologies is high, especially with blockchain applications, which require substantial resources and may increase the overall system cost. Second, data privacy protection is a critical issue. While blockchain can enhance data security, ensuring the privacy of personal health data and its compliant use still requires further research. Network performance and stability are also challenges, as IoT devices may experience transmission delays and load issues when applied on a large scale, reducing system efficiency. Therefore, future efforts need to focus on optimizing technology, controlling costs, and ensuring privacy protection to enable the broader application of this model across different user groups.

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