



# A Dynamic Monitoring Method for Marathon Athletes Based on Wireless Sensor Network

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**Abstract.** Due to the continuous development of the Internet, mobile devices are widely used, and wireless sensor networks have new application significance in the dynamic monitoring of athletes' physical fitness. It is currently a new research hotspot in the field of physical fitness monitoring of marathon athletes. According to the prescribed evaluation indexes of athletes' competitive ability, use wireless sensing technology to monitor the real-time dynamics of athletes' physical training and obtain athlete data results. According to the monitoring data, the athlete's physical training implementation can be reasonably adjusted, so as to standardize the athlete's training method and improve the quality of training. The marathon athlete's dynamic monitoring method based on wireless sensor network proposed in this paper can better guide athletes to improve their physical fitness, improve sports perseverance and explosive ability, stimulate their own potential, and improve the actual training effect. It has a great role in improving the training efficiency of marathon athletes per unit time, and at the same time, it is of great significance to realize the precise and personalized physical training plan of elite athletes.

**Keywords:** Wireless sensor network · Marathon · Fitness monitoring · Exercise energy consumption

## 1 Introduction

The wireless sensor network for dynamic monitoring of physical fitness training is not a new thing. Part of the function of sports science is to quantify the process of training by data and summarize it as a rule. In competitive sports, the collection and analysis of human movement data is an indispensable core of all sports analysis. In order to reduce sports injuries caused by high-intensity sports, the state of sports load can be monitored in real time. Using wireless sensor network nodes to collect sports load status parameters, to build a detection statistical feature analysis model, to achieve sports load status feature parameter spectrum feature analysis and real-time exercise status monitoring, and to achieve real-time monitoring and monitoring of high-intensity sports based on the monitoring results Health level test [1]. Sports physiology and biochemistry quantify the internal load of athletes to realize the control of athletes' functional state and fatigue degree. Sports training science and sports biomechanics quantify the external

performance of athletes in the process of training and realize the management of athletes' competitive performance. Due to the limitations of equipment and technology, it was formerly difficult to conduct real-time dynamic monitoring during training and immediately adjust the training content of athletes based on feedback. However, with the rapid development of the Internet, the dynamic monitoring system for athletes' physical fitness has been gradually improved. Athlete dynamic monitoring methods enable sports science practitioners to effectively collect athletes' physical fitness information and plan athletes' training load levels. Adjust the athlete's training method according to the actual competition needs to stimulate the athlete's own potential. Athlete dynamic monitoring can also help athletes reduce the risk of overload, optimize potential sports performance, promote physical function development, and improve actual training effects [2]. For example, a marathon athlete can accurately monitor the training load with a heart rate meter, and a cyclist can monitor the training load with a heart rate meter and a power meter. However, dynamic monitoring of physical fitness training involves different forms of movement and complex technical movements, so it is more difficult to achieve dynamic monitoring of wireless sensor networks [3]. Based on this, this paper discusses the dynamic monitoring method of wireless sensor network physical training, and enumerates a large number of elite athletes' real cases, expounds the important role of dynamic monitoring of wireless sensor network physical training in improving the quality of dynamic monitoring of elite athletes' physical training, and predicts that dynamic monitoring of wireless sensor network physical training will become an important direction of dynamic monitoring of physical training.

## 2 Dynamic Monitoring of Physical Fitness of Marathon Runners

### 2.1 Evaluation Index of Athlete's Athletic Fitness

Dynamic monitoring of physical fitness training can deeply excavate the potential of human movement. With the development of wireless sensor network technology, Dynamic monitoring of wireless sensor network has become possible [4]. The dynamic monitoring of wireless sensor network physical fitness training is an extension of traditional physical fitness training dynamic monitoring, which is a kind of training idea and concrete manifestation. The dynamic monitoring of physical fitness training in wireless sensor network is a two-way process, which is of great significance to improve the training efficiency per unit time and to realize the precise and personalized dynamic monitoring of elite athletes.

With the continuous improvement of modern sports science theory system, especially the development and improvement of sports training discipline theory, people have a more and more clear understanding of the essence of sports training and its internal laws [5]. The research on the structure and elements of athletic ability of athletes further clarifies the important position and function of dynamic monitoring of physical strength and physical training in modern sports training system [6]. At the same time, people have a more accurate understanding of the content and task of the dynamic monitoring of physical fitness training. Athlete's physical fitness, as a major component of competitive ability, plays an increasingly prominent role in sports competition [7]. Based on this, this

paper analyzes the influencing factors of athletes' competitive ability, and the concrete structure is shown in Fig. 1.

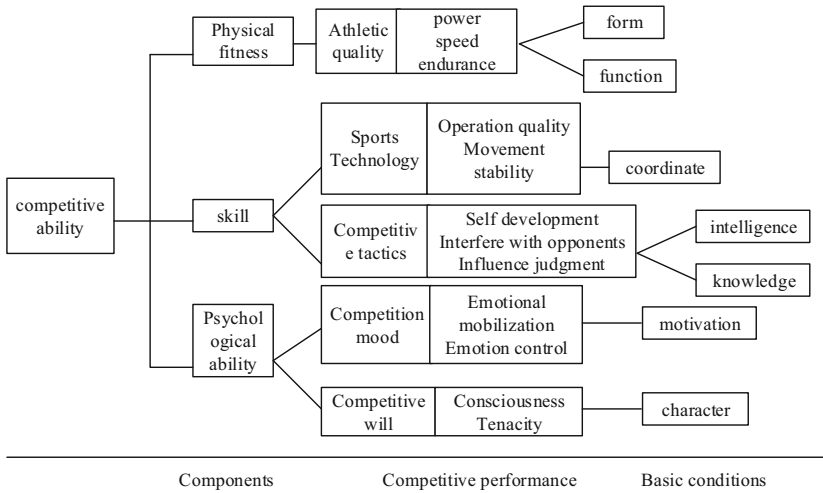


Fig. 1. The constitution of athlete's physical strength

According to the theory of sports training, physical fitness is an important part of athlete's competitive ability, and it is the basic ability of athlete's body. To establish the evaluation index system, the first thing is to determine the object and goal of the evaluation. This study chooses the special physical fitness of elite male marathon runners as the evaluation object, and then determines the index system, determines the weight

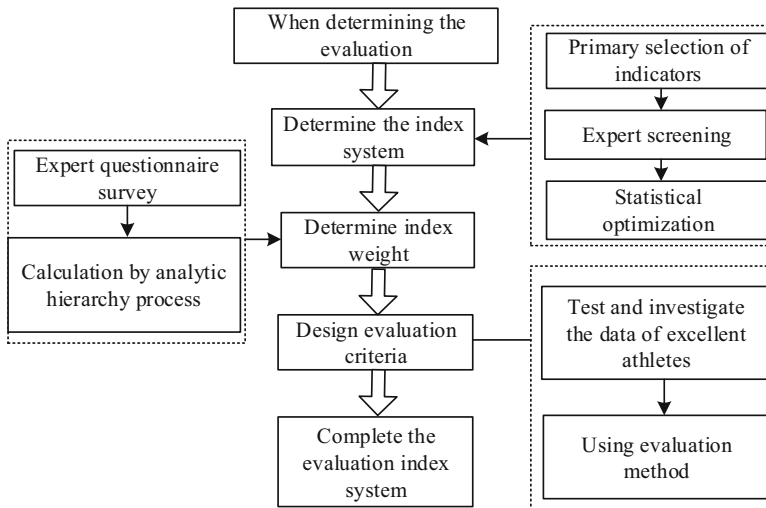


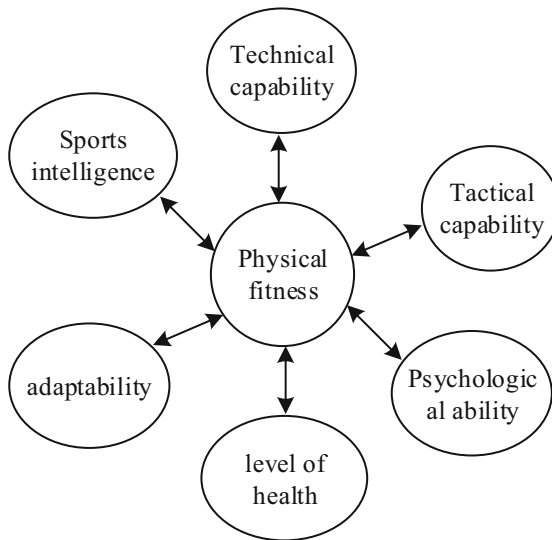
Fig. 2. Athlete fitness evaluation index system

of each index, sets the evaluation standard for physical fitness training, and finishes the construction of the whole system. The specific structure is shown in Fig. 2.

Because of the long-term nature of the dynamic monitoring process and the complexity of the influencing factors, coaches and researchers need to continuously monitor and evaluate the training state of athletes. After the construction of the evaluation index system is completed, the marathon athletes need to be put into training for trial, so as to guide the dynamic monitoring of marathon athletes' physical training. Provide more comprehensive monitoring and management for the dynamic monitoring level of marathon athletes' physical fitness training, improve the training effect, and finally achieve the goal of improving athletes' competitive level [8]. At the same time, according to the results of evaluation and some practical problems encountered in the evaluation process, constantly modify the evaluation index system, improve the evaluation function.

The dynamic monitoring of physical stamina training is a comprehensive project involving many subjects and fields. The important role and value of dynamic monitoring of physical fitness training on athletes' competitive ability and mass physical health have been re-recognized and widely recognized [9]. At present, the research on dynamic monitoring of physical fitness training in our country still lags behind the developed countries in Europe and America, and is still in the period of introducing and learning advanced theories and methods of dynamic monitoring of physical fitness training abroad. We should pay more attention to the research and application of specific practical problems when we are engaged in basic theoretical research. Generally speaking, the function of training monitoring is flexible and changeable. The main study is engaged in sports and competitive activities of special groups of people's physical fitness, the study is the physical function of athletes, so we must put the athlete's physical system in a larger system one athlete's competitive ability system for research [10]. Explore its function in this system, and the function of physical fitness system is always shown in the interaction with other factors, such as: technical ability, tactical ability, psychological ability, athletic intelligence, and the impact of health level and environmental factors. Based on this, the relationship between physical fitness training and competitive ability factors is analyzed, as shown in Fig. 3.

Physical fitness refers to physical ability, then dynamic monitoring of physical fitness training refers to the development of human physical fitness training activities of the general term. The general objective of dynamic monitoring of physical fitness training is to fully develop the physical activity ability of the human body, promote the improvement of morphological structure and physiological function, and improve the physical fitness level of the human body to meet the needs of sports [11]. In the field of competitive sports, dynamic monitoring of physical fitness training is a sub-goal under the general goal of sports training. It serves for the superior goal together with other sub-goals, such as technical training goal, tactical training goal and psychological training goal. The dynamic monitoring of physical fitness training is composed of several sub-targets. According to the four extensions of the physical fitness concept, the objectives of dynamic monitoring of physical fitness training include four aspects: to improve the physical structure; to comprehensively improve the physiological functions of various organs and systems of the human body; to fully develop various physical qualities; and to enhance the adaptability of the body.

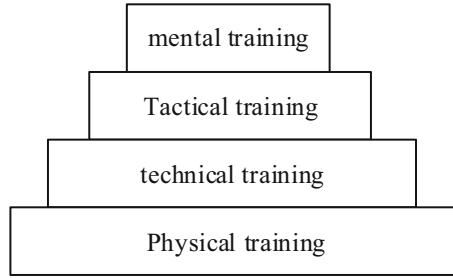


**Fig. 3.** Relationship between physical fitness training and competitive ability

Dynamic monitoring of physical fitness training is of great significance to both physical exercise and athletic competition. Without good physical fitness, people will not have overall health in the modern sense, and athletes will not have high level of technical and tactical performance. Dynamic monitoring of physical fitness training is the basis of other training, which is of great value to the improvement and maintenance of athletes' competitive ability.

## 2.2 Structural Elements of Dynamic Detection in Physical Fitness Training

It is recognized that the dynamic monitoring theory system of physical fitness training is an indispensable and important part of the discipline system of sports training. The dynamic monitoring theory of physical fitness training has experienced a long course of self-development and improvement. With the development of science and technology, people's understanding of physical fitness and dynamic monitoring of physical fitness training has been deepened, forming a multi-disciplinary, multi-disciplinary integration of emerging disciplines theoretical system [12]. The theory system of dynamic monitoring of physical fitness training is produced and developed in the field of sports training. Athlete's physical fitness, as an important sub-item of competitive ability, is highly valued and has a very strong meaning of specialization, which is the basic link in sports training. The fundamental goal of training monitoring is to develop the human body's exercise ability, and the basic material basis of exercise ability should be the human body's physical ability [13]. Therefore, in the large system of sports training, dynamic monitoring of physical fitness training is indispensable as a process of specialized transformation of the basic elements of athletic ability, and is also the basic condition of other training monitoring activities (Fig. 4).



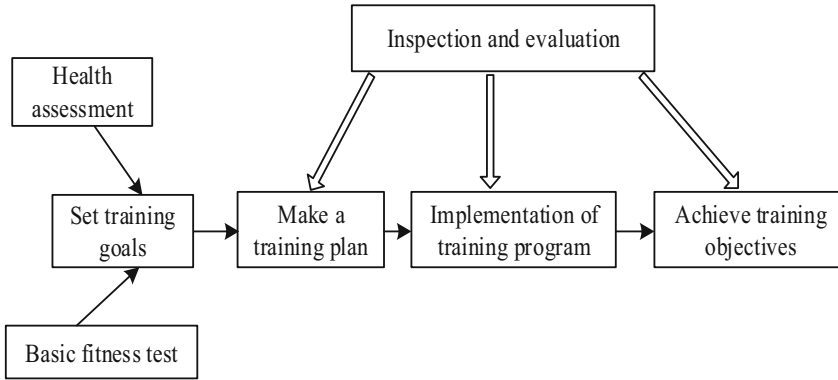
**Fig. 4.** Structural elements of sports training

In the practice of dynamic monitoring of physical fitness training, it involves the knowledge of many sports science, such as human anatomy, sports physiology, sports biomechanics, sports biochemistry, nutrition, psychology, and so on. Therefore, it can be said that the dynamic monitoring of high-level athletic training is the closest combination of scientific research on sports human body and training practice.

### **3 Dynamic Monitoring of Physical Fitness of Marathon Runners Based on Wireless Sensor Network**

#### **3.1 Athlete Fitness Data Collection**

The rapid development of wireless sensor network technology makes it possible to monitor the athlete's state in marathon training. Through RFID and wireless sensor, the athlete's state can be fully sensed, captured and measured, and the acquired data can be transmitted to the data processing center via the Internet for analysis and processing, so as to provide the coaches with the best guidance scheme, thus helping them to monitor and guide the training of athletes in real time. The dynamic monitoring of marathon athletes' physical fitness is the design and grasp of training process. The whole process of dynamic monitoring of marathon athletes' physical fitness is essentially the process of athletes' competitive ability changing from the actual state to the target state. It is the precondition of making dynamic monitoring plan of physical training and the basis of evaluating training effect to test and evaluate athletes before they start dynamic monitoring of physical training. Based on this, the dynamic data of physical fitness training is first collected, as shown in Fig. 5.



**Fig. 5.** Dynamic data acquisition process for physical fitness training

The energy consumption of human body should be considered when collecting physical energy data in wireless sensor network. However, the basic daily energy consumption (BEE) of the human body is subject to certain standards. Due to the physiological differences between men and women, the corresponding formula for calculating BEE is different, as follows:

$$\begin{aligned}
 & \text{MAN BEE (kcal)} \\
 & = 66.5 + 13.7 \times W + 5.0 \times H - 6.8 \times Q
 \end{aligned} \tag{1}$$

$$\begin{aligned}
 & \text{WOMAN BEE (kcal)} \\
 & = 65.1 + 9.56 \times W + 1.85 \times H - 4.68 \times Q
 \end{aligned} \tag{2}$$

In Eqs. (1) and (2), BEE takes kcal as the unit of calculation, 1 kcal = 4.184 kJ,  $W$  is weight (kg),  $H$  is height (cm), and  $Q$  is age (age). Since each index has different effects on physical stamina, it is necessary to define the judgment matrix by quoting the reciprocal  $x_{ij}$  as the scale, specifically as follows:

$$(x_{ij})_{n \times n} = \begin{bmatrix} x_{11} & x_{12} & x_{13} & \dots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ x_{n1} & x_{n2} & x_{n3} & \dots & x_{nn} \end{bmatrix} \tag{3}$$

In Formula (3),  $x_{ij}$  is the ratio of importance of the indicators, and  $n$  is the evaluation indicator. The index weight is calculated by arithmetic average method. The arithmetic average method is described by mathematical formulas as follows:

$$w = \frac{1}{m} \sum_{j=1}^n x_{ij} \cdot \alpha \tag{4}$$

In formula (4),  $m$  is the weighted average coefficient and  $\alpha$  is the saturation weight. Using this formula, we can accurately calculate the weights of each index in Table 1 and make full preparation for the follow-up physical fitness assessment.

The three-axis acceleration generated by human motion is collected by wireless network sensor, and the energy consumption of human motion is calculated at  $E$ . The formula is as follows:

$$E = \frac{d}{2w} u \cdot g \tag{5}$$

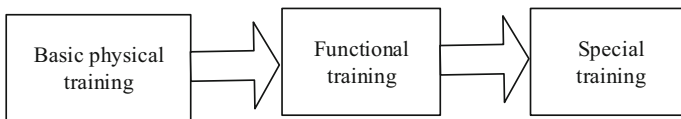
In formula (5),  $u$  is the training frequency,  $d$  is the training intensity, and  $g$  is the acceleration in the training process ( $g = 9.8 \text{ m/s}^2$ ). Further, the human body energy information collected by the sensor is drawn, displayed in the mode of three-dimensional coordinates, and the characteristic value is output on X, Y, Z triaxial axis and converted to the geometric average generated after the acceleration of each axis. The calculation formula is as follows:

$$G = M \sqrt{(E_x^2 + E_y^2 + E_z^2) / 3w} \tag{6}$$

In Formula (6),  $E_x^2, E_y^2, E_z^2$  is the curve change of each axis after treatment respectively. According to the results of the evaluation and the actual problems encountered in the evaluation process, constantly modify the evaluation index system and improve the evaluation function.

### 3.2 Construction of Physical Fitness Monitoring System

Based on the results of training monitoring, a series of movement combination models are designed to get close to the characteristics of special sports techniques to the greatest extent. Functional training focuses on the training of the whole dynamic chain, emphasizes the integrity and control of the generation and transmission of the whole exercise force, and enhances the balance and the proprioception of neuromuscular system. Functional training is a dynamic monitoring method of physical training, which is based on basic physical ability and more similar to special technical movement characteristics. Based on this, the monitoring factors of athletes' physical fitness training are further analyzed, as shown in Fig. 6.

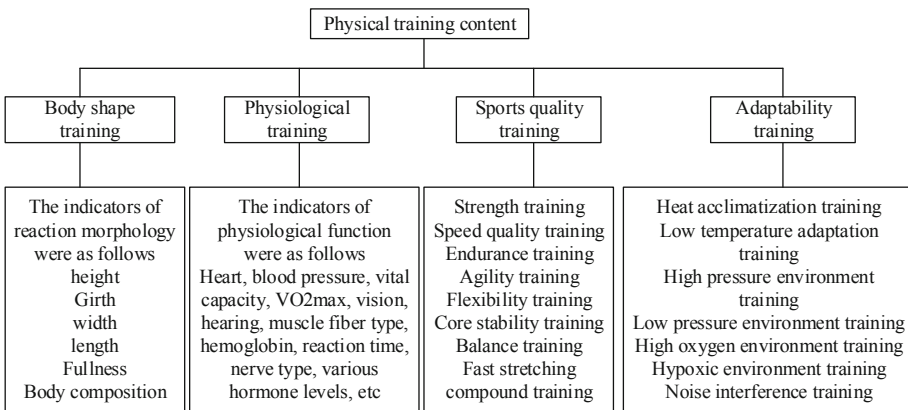


**Fig. 6.** Monitoring factors of athlete physical fitness training

As shown in Fig. 6, the dynamic monitoring process of modern physical fitness training is a scientific, rigorous and standardized operation process, which is divided into five closely connected processes: exercise capacity measurement, physical fitness assessment, scientific design of dynamic monitoring plan of physical fitness training, formulation of physical fitness development goals and implementation of dynamic monitoring of physical fitness training. How to define the nature of physical fitness coaches

is the key problem to break down all layers of obstacles and establish a professional training system of physical fitness coaches as soon as possible.

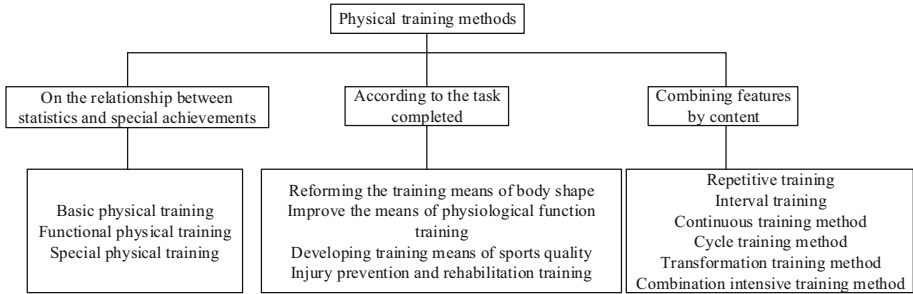
Based on the analysis of the components of physical fitness structure, the dynamic monitoring of physical fitness training should include the transformation of body shape and structure, the improvement of physiological function, the development of sports quality and the enhancement of physical adaptability. Therefore, the dynamic monitoring of physical fitness training is to develop physical fitness by training the sports quality of physical performance, and to achieve the training goal of profoundly influencing and changing the physical form, physiological function and improving the adaptability of the body by developing the sports quality closely related to the special competitive ability of athletes, such as strength, endurance, speed, flexibility, agility and coordination. But with the development of training theory and practice, these six qualities can not reflect all the contents of dynamic monitoring of physical fitness training. Based on this, the methods of core stability training, balance ability training and rapid telescopic compound training are put forward. Supplementing the original dynamic monitoring system of physical stamina training, the dynamic monitoring system of physical stamina training with various physical stamina as the main body is formed (Fig. 7).



**Fig. 7.** Monitoring system of physical fitness training

Training monitoring is to achieve the goal of sports training, according to the specific training content and design and use of specialized training means or behavior of the general term. Training method is the core content in the theoretical system of special training, and other factors are the supporting conditions for the implementation of training method. The main factors of sports training methods are exercise and its combination, exercise load and its changing way, process arrangement and its changing way, information media and its transmitting way, external condition and its changing way. Different combinations of these elements and their changes can form a variety of training methods with different functions. The physical training process is also the process of making training plans and implementing them. According to the periodical division of training stages in sports training science, the training of athletes can be planned and organized by stages. Training plans of different length can be made, such as multi-year

training plan, annual training plan, stage training plan and weekly training plan. Regardless of the length of training time, each training process should include basic contents such as athletes' health status and risk assessment, basic physical fitness assessment, determination of training objectives, formulation of training plans, implementation of training programs, and inspection and evaluation. In the dynamic monitoring system of physical fitness training, according to the principle of taxonomy, different classification systems can be established according to different classification standards (Fig. 8).



**Fig. 8.** Health information monitoring system for physical fitness training

According to the relationship between training and special achievements, it can be divided into dynamic monitoring of basic physical fitness training, which mainly refers to the dynamic monitoring of physical fitness training to ensure the health level and the physical quality and ability needed for daily activities. Dynamic monitoring of functional physical training is a kind of multi-plane compound movement training based on the theory of “dynamic chain of movement”, which strengthens body posture, movement pattern and dynamic stability. Dynamic monitoring of special physical fitness training refers to the dynamic monitoring of physical fitness training, such as the dynamic monitoring of special physical fitness training. According to the training task, it can be divided into training means to reform body shape, training means to improve physiological function, training means to prevent injury and rehabilitation training means. According to the characteristics of training content combination, it can be divided into repeated training method, intermittent training method, continuous training method, cycle training method, change training method, combination strengthening training method, etc. Dynamic Monitoring of Marathon Athletes in Wireless Sensor Network Environment Can Better Guide Athletes to Improve Their Physical Fitness.

## 4 Analysis of Experimental Results

In order to ensure the effectiveness of the dynamic monitoring method for marathon runners in wireless sensor network environment, the expert validity test method is adopted. First of all, the questionnaire of this study is designed according to the design procedure of the questionnaire in the research content and the educational research method. The first draft of the questionnaire was designed on the basis of the consulted documents and

expert interviews, and 12 experts and coaches were selected to make a logical judgment on the validity of the content and structure of the questionnaire by adopting the method of expert evaluation. The validity of the content and structure of the questionnaire was assessed on the basis of five grades. More than 90% of experts believed that the questionnaire designed was effective and reasonable. The specific situation was shown in Table 1, 2 and 3.

**Table 1.** Expert composition table

	Expert	Coach
Number of people	7	5
Title/grade	Professor	National level

It can be seen from Table 1 that the evaluation objects of this experiment are 7 professor-level experts and 5 national-level coaches, so as to fully ensure the objectivity of the evaluation.

**Table 2.** Evaluation of the validity of the questionnaire by experts (N = 12)

	Very effective	Effective	Commonly	Not very effective	Invalid
Physical coach questionnaire	8	3	1	0	0
Q & A of competitive coaches	9	2	1	0	0

**Table 3.** Expert evaluation of the structural validity of the questionnaire (N = 12)

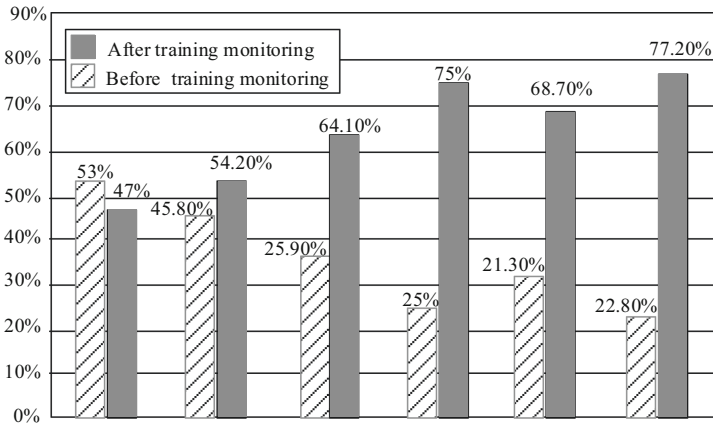
	Very reasonable	Reasonable	Commonly	It's not reasonable	Unreasonable
Physical coach questionnaire	7	4	1	0	0
Q & A of competitive coaches	6	3	2	0	0

From Table 2 and Table 3, we can know that experts and coaches fully affirmed the content and structure of the questionnaire, and believe that the marathon athlete dynamic monitoring method has a certain effect on content improvement, and has a certain degree of rationality in the structure. Based on this, the results of further aerobic endurance training 3–4 times a week also show that planned dynamic monitoring of physical training is effective. The results are shown in Table 4.

**Table 4.** Statistics of test results

Number of subjects	Test index	Preliminary survey	Unmeasured	Improved value
3	Beeb-test	10-1	11-1	1.1*
	Repeat Sprint (6 times, seconds)	35.6	31.6	4*

It can be known from Table 4 that the preliminary test index values obtained by the athletes’ training monitoring are relatively large, and there are many unmeasured data. Therefore, it is necessary to improve the overall data calculation ability of the system and optimize the test results. Further comparative analysis of athletes before and after training monitoring changes in physical fitness, the specific statistical results as shown in Fig. 9.



**Fig. 9.** Comparative analysis of monitoring results of athlete’s physical fitness

Based on the testing results in Fig. 9, the dynamic monitoring method of marathon runner based on infinite sensor can improve athletes’ stamina and explosive force. Improve the efficiency of training by stimulating the potential of the athletes themselves through enhanced feedback.

## 5 Concluding Remarks

The task of dynamic monitoring of physical fitness training is to carry out systematic, scientific and reasonable physical ability training according to the characteristics of athletes and the needs of sports competitions, so as to improve their special sports quality. As far as marathon runners are concerned, dynamic monitoring of physical fitness training can fully tap the potential of athletes and lay a solid physical foundation and key ability guarantee for their future racing and excellent sports results. Therefore, it is

very important to monitor marathon athletes' physical fitness training in a scientific way. Marathon athletes should focus on the future, reasonable planning, strict implementation and scientific control, which is the fundamental path of dynamic monitoring of marathon athletes' physical training.

This paper uses wireless sensing technology to monitor athletes' physical training, obtains the athletes' effective training data results, and makes reasonable adjustments to the athletes' physical training implementation based on the monitoring data, so as to standardize the athletes' training methods. The research on the dynamic monitoring method of marathon athletes' physical fitness based on the wireless sensor network is beneficial to improve the athletes' physical fitness, enhance sports perseverance and explosive ability, so as to achieve the training effect. However, due to the limited time and research conditions, the method designed this time still has shortcomings, and the results still have limitations. The confidentiality of the athlete's dynamic monitoring data has not been analyzed in detail. In the future research process, data security technology will be applied to the physical fitness dynamic monitoring system to further improve the privacy security of the system, and provide athletes with more reliable training methods, with a view to monitoring the physical fitness training dynamics of Chinese marathon athletes and marathon reserve Talent training provides suggestions and references that can be used for reference.

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