Application of UWB Technology in the Development of Football Training Load Monitoring System

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Abstract — To control the training load of football players in a more scientific and reasonable way. Method: Establishing the football training load monitoring system based on ultra wideband (UWB) technology. Process: The article introduced the meaning and advantages of UWB technology, established a model of soccer training load monitoring system based on UWB technology, and displayed the development trend of scientific training monitoring mode of the future football. Result &Analysis: This article used the mathematical theory to elaborate the established monitor system model, carried out data statistics and analysis of the application of this model in soccer training, and found that this monitoring system can supply scientific and reasonable sports data and physical condition information of the football players for the coaches. Result: The football training load monitoring system based on UWB technology can effectively monitor the training load of football players.

Keywords - UWB technology; Football training; Monitoring system; Training load

I. INTRODUCTION

Football is a combination of aerobic and anaerobic movement, in fact it’s a kind of continuous movement with repeated sprints of short distance and high intensity. When making the training plan of football sports, it is very important to understand the running mode and running distance of an athlete.

All kinds of running should be classified and measured according to the type, intensity, duration and frequency, etc., and through this kind of training load monitoring, the overall situation of a race or a training session can be described. When the information of running distance, running intensity, duration, heart rate, etc., are combined together, it can objectively reflect the movement pattern of the physiological significance of football, and this can provide more impersonal and scientific theoretical basis for the development of more objective and effective training plan [1]. Figure 1 (a) - (c) are several different kinds of football training courses.

Ultra wide band (UWB) technology is a kind of communication method without carrier, using the pulse of minimal time interval, and it's also a kind of communication technology, which can be used for accurate tracking and real-time positioning, in wireless personal area network with low power consumption and high speed transmission.
its characteristics, such as high positioning accuracy, small positioning tag size, long power-supply time, large data storage capacity, high-speed data transmission and so on, all can meet the requirements of the development of football training load monitoring system [2]. We can research the training load monitoring system of more objective, more accurate, easier to use, and capable of real-time feedback by providing the training with high technology and equipment, to monitor the training loads and movement patterns of soccer players effectively, and carry out dynamic analysis of the collected data, thus this monitor system can provide more accurate related indicators and analysis of athletes, such as the fitness, displacement, speed, sports ability on the field, range of activities, heart rate and so on, in the training and competition, and it will help to improve the pertinence, effectiveness and creativity of the trainer's training, and can provide more effective technical support for the coaches [3].

II. RESEARCH ON THE DEFINITION OF THE CONCEPT OF TRAINING MONITORING

The emergence of the term “monitoring” in the training should be traced back to 1960s, at that time, the “diagnosis”, “biochemical criteria” and other words are used when using biochemical methods to monitor and assess the body metabolism and functional status of athletes. Until 1992, Uhl Hallson and Kim Deman formally put forward the concept of “training monitoring”. Into twenty-first century, based on the study of Europe and America and the Soviet Union, Veall published a book named “Biochemical Monitoring of Sport Training”, which marks the preliminary formation of the monitoring system of sports training. Research on the concept of training monitoring in our country, is explored by related scholars from different perspectives in depth, it is considered as the application and practice of the theory and method in the field of sports training. For example, Lianshi Feng from the physiological and biochemical point of view thought that the training monitoring is to put the theory and method of sports medicine, sports biomechanics, sports psychology and sports biochemistry, etc. into the training process, to help the coaches adjust the training plan, and maximize the training effect and the ability to exercise [4]. Hong Ping, one of our country’s scholars, have also conducted a systematic study on this problem and thought that training monitoring is an important method for the coaches to implement the control, the actual effect of the training control is not possible to achieve the intended target. Therefore, the use of training monitoring can find the deviation between the actual results and the intended target, and make timely correction and adjustment to ensure the best training objectives. Dachao Zhang has put forward different views on the definition of the concept of the training monitoring of Hong Ping, He considers that the monitoring of the training process is not only the monitoring of the training effect, but also includes the same important various factors affecting the implementation process in the monitoring. Maiju Tian, the scholar of our country, explained the training control, in “Sports training terms”, as: will be trained to control the training of the sports training: To grasp and adjust sports training activities through special methods and means, in accordance with the established direction and purpose [5]. Chinese scholars Liu Dan also believes that the success of the competition is not the ultimate goal of monitoring, but the start of a new training phase. The monitoring process is made up of numerous training stages and numerous successful entries, it’s a never-ending process. Training monitoring is the core content of scientific training, and an important symbol of the scientific training.

Although many scholars have defined it from different perspectives, its core content is able to form a certain consensus. It can be seen from the perspective of information theory, control theory and system theory, the monitoring process includes two processes: training monitoring and training control, and it starts from the realistic conditions for the purpose of improving the competitive ability and getting the victory of competition. Scientific control to the whole training process is the core content of training monitoring [6].

III. ADVANTAGES OF UWB TECHNOLOGY

Compared with other wireless communication technologies, the UWB technology has the following characteristics: high transmission rate, large capacity, strong anti-multipath capability, low power consumption, and low cost. It transfers information by varying the amplitude, spacing, or duration of the pulse. Compared with the narrow-band transceiver and bluetooth transceiver, UWB does not need to generate a sinusoidal carrier signal, while it can transmit the impulse sequence directly, so it has a broad spectrum and a very low average power, which is conducive to coexistence with other systems and improve the spectrum utilization ratio [7]. UWB does not need a sine wave modulation or upper and lower frequency conversion, also does not need the local oscillator, power amplifier and mixer ect. so it has small size and simple system structure. Its signal processing is also relatively simple, which just uses a few radio-frequency (RF) or microwave devices. RF design is simple, and the system’s frequency adaptive ability is strong. We can integrate a pulse transmitter and the front end of a receiver into a chip, and add the time base and controller, these can constitute an UWB communication equipment. Therefore, its cost can be greatly reduced. Since the UWB signal has adopted spread spectrum, its RF bandwidth can reach 1 GHz or more, and its power spectrum density of emission is very low, the signal is hidden in the environment noise and other signals, so the traditional receiver is unable to receive and recognize the signal, while we must use the pulse sequence of the spread spectrum code same as the originator to decode it, so the security of the system is increased [8]. The fading of UWB signal is low, and its anti-multipath-fading capability is strong. And the large broadband of UWB signal has brought huge system capacity, because the duty ratio of transmitting impulse of the UWB radio signal is extremely low, the system has a high gain and strong multipath resolution, so the system capacity is higher than...
Because of the large processing gain of spread-spectrum of UWB signal, even using low gain omnidirectional antenna, a few kilometers of communication can also be implemented using a transmit power of less than 1 mW. Such a low transmission power extended the using time of the system power, which is very suitable for mobile communication equipment. Some research shows that standby time of ultra-wideband mobile phone can reach 6 months, and low radiation power can avoid the radiation damage of excessive electromagnetic to the human body [10]. UWB is aimed at high-speed wireless network connection in a distance of 30 feet, and can replace the USB cable in connection with home entertainment devices. IEEE (Electrical and Electronics Engineers Institute) has established a working group of the IEEE 802.15.3a technology standards, but it's in a stalemate situation that whether use the MBOA technology or use the direct sequence technical supported by Motorola and other manufacturers. In order to complete the two kinds of super wireless broadband technology specification, and provide them to professional UWB manufacturers such as Intel, TI, HP, SONY, Staccato, Alereon and so on, MBOA has established a special interest group, which has started the production of the corresponding volume of chip from mid of 2005 [11]. In order to ensure the smooth progress of the whole system, so as to make its technology more compatible with other software layers. The special interest group also cooperate with standards bodies in addition to the completion and promotion of OFDM specifications. Freescale company, supporting for the direct sequence UWB, has questioned the prospects of MBOA standards. “Direct sequence” technology is aimed at short distance communication, Freescale’s first generation chip can provides a data transfer rate of 1 Gbps in the distance of more than 10 metres [12].

IV. AN OVERVIEW OF FOOTBALL TRAINING MONITORING SYSTEM

The establishment of football training monitoring system is becoming more and more mature, there is a more unified understanding of the definition and process of training monitoring, which emphasizes on the two processes of training monitoring and training control, starts from the realistic conditions, for the purpose of improving the competitive ability and getting the victory of competition [13].

In the aspect of body function monitoring, there are body function level monitoring and monitoring of physical function, and the first one usually includes the aerobic function monitoring, anaerobic function monitoring, and the muscle function monitoring. While the second one usually includes blood index monitoring and function monitoring of nervous system. Specific monitoring indicators can be selected and integrally tested according to the purpose of training, in order to analyze the characteristics and changing rules of the athletes' function state, and predict the change trend of functional state of athletes.

In the aspect of training load monitoring, the main monitoring objects are the training course load, training stage load and load of special period or place. The adaptation of athletes to training load can be learned by testing their various physiological and biochemical indexes, that has important significance to the athlete's body recovery and the trainer's training arrangement and so on [14].

In the aspect of physical fitness monitoring, establishing scientifc athlete selecting criteria, training mode and training monitoring system, according to the characteristics and laws of football players in different positions on the field, is the development trend of the physical quality of the football players in the present stage. The evaluation and establishment of physical quality are composed by the speed, strength, endurance, flexibility and sensitivity the 5 factors. In the process of monitoring, it is necessary to make sure that the evaluation of the football players is in a targeted manner, so as to highlight and combine special features of the football sports.

In the aspect of psychology and nutrition monitoring, the evaluation of body composition, the investigation of dietary status, the evaluation of diet, individual psychological state monitoring and team cohesion construction are the core contents of the monitoring.

V. APPLICATION OF UWB TECHNOLOGY IN FOOTBALL TRAINING LOAD MONITORING SYSTEM

The heart rate in the training and the match can reflect the load intensity of the athletes, the comparison and analysis of distribution of heart-rate intensity in multi matches can reveal many factors that affect the performance of sports competition, and provide the basis for the coaches...
to develop training plan. The determination of heart rate at the same time of determining the running distance and the running intensity, the analysis of the load intensity of athletes in training and competition, and the analysis of the athlete's sports ability and recovery ability are very meaningful. This study will install UWB tag, heart rate collection and integrated transmission block on the heart rate strap, high-precision positioning information is transmitted to the processor by UWB wireless positioning technology, the sampled heart-rate data is transmitted to the processor by the mean of wireless acquisition and transmission, in order to obtain the heart rate and positioning data, can simultaneously provide the heart rate and the running distance, that's to say, the related data of heart rate, running distance, running intensity, etc. can be provided simultaneously.

A. The Structure Design of the Monitoring System of the Football Training Load

The network topology is used to arrange the training load monitoring system, as shown in Figure 3.

The reference tag is put on the goal to get the location information of location tag, and there are 8 base stations around the football field, correspondingly there are 8 receivers at the right places, in order to receive the positioning information of location tag in the range of the entire football field. The information received by the receiver is transmitted to the hub processor, and transmitted back to the computer system through the wireless network, then the data and the heart rate data will be processed by the relevant software [15].

B. Heart-Rate Data and Location Data Collection

Real-time collection of heart rate data was done by Bluetooth heart-rate collecting belt; Data acquisition module of ultra low-power consumption obtains data through the Bluetooth interface and Bluetooth heart-rate belt, and then transmit the gained data to the collection terminal or database through GPRS; The software of the notebook computer carries on the centralized processing to locate the data and the heart rate data. The expression of the load intensity of the motion is:

\[
\text{Load intensity} = \frac{HR_{\text{exercise}} - HR_{\text{rest}}}{HR_{\text{max}} - HR_{\text{rest}}} \tag{1}
\]

Where \( HR_{\text{exercise}} \) is the exercise heart rate, \( HR_{\text{rest}} \) is the quiet heart rate, and \( HR_{\text{max}} \) is the maximum heart rate.

\[
\text{Average load intensity} = \frac{\sum_{i=1}^{n} \left( HR_{\text{exercise}} - HR_{\text{rest}} \right)}{1080} \tag{2}
\]

Maximum load intensity = \( \frac{HR_{\text{exercise, max}} - HR_{\text{rest}}}{HR_{\text{max}} - HR_{\text{rest}}} \) \( \tag{3} \)

Where \( HR_{\text{exercise, max}} \) is the maximum heart rate in the race.

C. Software Platform for Training Load Monitoring System

The software can analyze and manage the collected positioning data and heart rate data. It can not only carry real-time visual management to the acquisition data, but also carry out data analysis and chart analysis. At the same time, the software is required to be able to run on the server computer and the client computer, for the management of authorized personnel, the software is convenient for the analysis and management of the football players training. According to the needs of football project, the software console page can directly carry out data statistics such as: The total running distance, the fastest speed, the running distances of different intensity, the appearing number of...
different intensity, the average heart rate, the maximum heart rate, and the percentage of different intensity. The software is divided into 5 parts, as shown in Figure 4.

VI. Analysis and Evaluation of Football Training Load

The evaluation of the training course is evaluated from three aspects: the quality of the course, the load of the course, and the means of the training. The evaluation indicators of the training load are the eight representative indicators selected from 20 indicators. The choice of these eight indicators is based on the characteristics of the training quality, and also be helpful of guiding the improvement of the football level. The first evaluation step of the course is to calculate the average and standard deviation of each index, the next step is setting the mean value was 50 points, then the values, which are 2.5 standard deviation above the average value, are determined as 100 points, finally, the grades of the scores are arranged in order. If the average value of the index i is \( a_i \), and its standard deviation is \( \sigma_i \), when the index value is \( X \), the calculation formula of the value \( M_i \) is:

\[
M_i = \frac{20}{\sigma_i} \cdot (X - a_i) + 50 \quad (4)
\]

Finally, the total evaluation value \( M \) of the training course is:

\[
M = \frac{1}{8} \sum_{i=1}^{8} M_i \quad (5)
\]

The quantitative standard for the load of various classes is shown in Table 1.

<table>
<thead>
<tr>
<th>150- time heart rate(minute)</th>
<th>170- time heart rate(minute)</th>
<th>Average heart rate (times/minute)</th>
<th>The total number of skills(times)</th>
<th>Total distance (m)</th>
<th>Motion density (%)</th>
<th>Exercise density (%)</th>
<th>Basic time</th>
<th>Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>58</td>
<td>32</td>
<td>146</td>
<td>280</td>
<td>4671</td>
<td>46</td>
<td>90</td>
<td>102</td>
<td>strong</td>
</tr>
<tr>
<td>48</td>
<td>26</td>
<td>136</td>
<td>239</td>
<td>4002</td>
<td>39</td>
<td>86</td>
<td>94</td>
<td>a little strong</td>
</tr>
<tr>
<td>38</td>
<td>19</td>
<td>129</td>
<td>198</td>
<td>3334</td>
<td>33</td>
<td>81</td>
<td>85</td>
<td>medium</td>
</tr>
<tr>
<td>28</td>
<td>13</td>
<td>121</td>
<td>157</td>
<td>2666</td>
<td>26</td>
<td>76</td>
<td>77</td>
<td>general</td>
</tr>
<tr>
<td>18</td>
<td>6</td>
<td>112</td>
<td>116</td>
<td>1997</td>
<td>19</td>
<td>71</td>
<td>68</td>
<td>weak</td>
</tr>
</tbody>
</table>

The data in this table are extracted from the data of the football training load monitoring system, it can be seen that the monitoring system can effectively feedback the athletes' movement data and physical quality information, which provides scientific and reasonable basis for setting training load evaluation standard, and also provides scientific support for the development of the future football.

VII. Conclusion

UWB technology has brought a new concept for the crowded radio spectrum, its innovative using models and product characteristics are attracting the global attention. It can be applied to the development of the football training load monitoring system. Besides, through the development of related software, it can provide a powerful data analysis and statistical functions, and provide more scientific and objective basis for the training of the coaches.

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References


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