J. COMBIN. MATH. COMBIN. COMPUT. 127a (2025) 3197--3212

Journal of Combinatorial Mathematics
and Combinatorial Computing
www.combinatorialpress.com/jcmcc

The Design of Smart Wearable Devices and Real-Time Data Feedback in Athletic Performance Enhancement in Athletic Training

Qinhai Wang[1,✉]

[1] *College of Physical Education, Huaqiao University, Quanzhou, Fujian, 362021, China*

ABSTRACT

The application of modern information technology in track and field training has become an important means to improve the training effect. The study analyses the application of smart wearable devices in track and field training, takes the real-time feedback data of smart wearable devices as the index observation point, constructs the evaluation index system of track and field training based on smart wearable devices, and explores the application of factor analysis and fuzzy comprehensive evaluation method. On this basis, teaching experiments are carried out using smart wearable devices and the evaluation system to explore the effect of smart wearable devices on the enhancement of track and field training in athletic performance. The track and field training of the students in the sample colleges and universities was of medium level, with a total score of 73.71, in which the development of students' will quality and teachers' grasp of the training situation still need to be improved. After training with smart wearable devices and assessment system, the practicing students got 4.09%~5.01% improvement in standing long jump, 50m run and 800m run, and there was also a significant difference in training interest with the control students ($P<0.05$). The smart wearable device and evaluation system can achieve real-time data monitoring and training feedback, which can help coaches and students adjust training in time and improve the effect of track and field training.

Keywords: factor analysis, evaluation index system, fuzzy comprehensive evaluation, smart wearable devices, track and field training

1. Introduction

With the penetration of information technology in the education industry, it has already had a profound impact on teaching and learning. Youth track and field training as an important part of

✉ Corresponding author.
E-mail address: wqhsdzibo001@163.com (Q. Wang).
Received 25 January 2024; Revised 15 March 2024; Accepted 05 December 2024; Published Online 15 April 2025.
DOI: 10.61091/jcmcc127a-181

cultivating track and field talents, scientific and advanced training methods and means are crucial for improving the training effect and competitive level of athletes [1-2]. Traditional track and field training methods often rely on coaches' personal experience and athletes' self-conscious training, and there are problems such as single training method and low efficiency. And the emergence of modern information technology has brought new opportunities for track and field training. Such as big data, artificial intelligence, Internet of Things, etc., provides a more scientific and efficient way for track and field training [3-4]. Through big data analysis, it can accurately grasp the training status of athletes, physical changes and other information, and develop a more scientific training plan for coaches. Through artificial intelligence technology, the movement of the athlete is analyzed, which can help the athlete to correct the technical movement and improve the training effect. Through the Internet of Things technology, it is possible to collect and transmit athletes' training data in real time, so that the coaches can master the training situation of the athletes at any time and adjust the training program in time [5-6].

Although the application of modern information technology in track and field training is promising, there are still some problems in youth track and field training [7-8]. For example, some coaches have insufficient knowledge of modern information technology and lack relevant skills, and some schools have not invested enough in information technology application, resulting in a low level of information technology application. Therefore, it is very meaningful to explore the status quo and problems of the application of modern information technology in youth track and field training, and put forward corresponding countermeasures on this basis, which is very meaningful to improve the science and effectiveness of youth track and field training [9-10].

Smart wearable devices are a product of the combination of modern technology and sports training, and play an increasingly important role in track and field training. Smart wearable devices utilize advanced sensors and algorithms to monitor and record athletes' physiological data in real time, providing coaches and athletes with more accurate training feedback. First of all, smart wearable devices such as heart rate monitors, step counters and sports bracelets are capable of real-time monitoring of athletes' physiological data such as heart rate, respiratory rate, number of steps, distance and calories burned. These data can help athletes and coaches to have a clearer understanding of athletes' training status and degree of recovery [11-12]. For example, heart rate data can reflect an athlete's fatigue level and exercise intensity, while the number of steps and distance can measure an athlete's exercise volume and energy consumed. Second, through the data collected by smart wearable devices, coaches and athletes more accurately understand the training status of athletes, so as to develop a more scientific and reasonable training program. According to the data of the athlete's heart rate, step count and exercise intensity, the training intensity and training volume are adjusted to avoid over-training or under-training. Furthermore, smart wearable devices can also promote the independent training of athletes. Athletes know their training data and physical condition in real time through these devices, and make training adjustments according to their own situation [13-14]. Finally, they can help athletes better recover and manage their health. By monitoring athletes' sleep quality, heart rate, and step count, etc., it assesses athletes' recovery and health status, and provides athletes with recovery suggestions and health management programs to help them better recover their physical strength and improve their training effects. Therefore, introducing wearable smart devices into university track and field teaching and utilizing the advanced functions and data analysis capabilities of intelligent devices are expected to bring revolutionary changes to track and field teaching. By monitoring students' exercise data in real time, physical education teachers can more accurately understand students' learning progress and physical condition and provide them with more scientific training suggestions [15-16].

The development of information technology has facilitated the reform and innovation of sports training, which has effectively improved the training effect of athletes during sports training by real-time monitoring, real-time analysis of athletes' training movements as well as physiological indexes, and real-time guidance. Foster, C et al. illustrated the development and evolution of training monitoring strategies in sports training, ranging from intermittent training testing to in-house training loads that require laboratories to go for calibration monitoring, and the recent rise of wearable device-based training monitoring, which has deepened the knowledge and understanding of IT-enabled sports training monitoring [17]. Appelbaum, L. G et al. discussed the importance of athlete vision for game competition and provided a systematic overview of the methods and future trends of virtual reality-based sports vision training [18]. Hadlow, S. M et al. reviewed the literature on motion vision training and compared traditional motion vision training methods with motion vision methods using the MPT tool as the core logic, noting that the improved MPT vision training framework demonstrated good performance and that the method was more accurate in predicting the future visual performance of athletes [19]. Ma, B et al. based on the theory and concept of C/S model, designed a model for monitoring the training process of athletes, the model can synchronize the location of the athlete and can provide real-time guidance for athletes can also be tracked and analyzed based on the athlete's functional characteristics of the movement, as well as, physiological indicators and other data [20]. Mao, Y et al. developed a self-powered biosensor to monitor maximal lactate homeostasis in athletes, which was analyzed practically and confirmed to be effective in improving the efficiency of MLSS assessment and can be used in the development of intelligent assisted training systems [21]. Cannavò, A et al. conceptualized a sports training model with virtual reality technology as the underlying architecture and conducted research experiments to evaluate and test the model, comparing with video projection based training techniques, the virtual reality based sports training model is superior in terms of ability to localize time and space as well as gesture execution [22].

Reviewing the research on track and field sports mainly involves the development of track and field sports, the connotation of track and field sports and the benefits it brings to the human body as well as track and field training techniques, while the content of track and field training methods also contains wearable device-based track and field training and traditional track and field training methods. Macadam, P et al. systematically searched for the papers and reports on Wearable Resistance Training (WRT) and were informed that the wearable Wearable Resistance Training (WRT) strategy, possesses the ability to improve the running and jumping abilities of athletes, but the magnitude and direction of the load should be considered when training with this strategy [23]. Boltayevna, Z. F talked about the training methods of track and field and the health benefits of track and field for the human body, pointed out that track and field training needs to take into account the functional status of the individual body, the use of the appropriate equipment to carry out the appropriate exercises, and illustrated that track and field effectively improves the functioning of the human body organs, and improves the physical fitness of the human body [24]. Yuan, Y in-depth examination of track and field sports teaching and training strategies, as well as track and field sports teaching and training of the current development of the status quo and obstacles, and put forward a number of recommendations conducive to the innovative training of track and field sports, to improve the efficiency and effectiveness of track and field sports training to make a certain contribution [25]. Zhao, Y introduced the content and connotation of track and field sports program, pointed out that track and field is a sport to explore the human body running speed potential and quality of the sport, the need to continue to carry out long-term training at the same time to master a certain sports skills, and finally also summarized and analyzed the track and field sports training [26].

The study first discusses the value of smart wearable devices in track and field training from the theoretical level, combines the real needs of track and field training evaluation with the technical basis of smart wearable device technology, and selects the evaluation indicators of track and field training at the level of students and teachers after several rounds of consultation to determine their corresponding observation points of smart wearable devices. Afterwards, factor analysis was used to reduce the dimensionality of the evaluation indexes and complete the assignment, and then combined with the fuzzy comprehensive evaluation method to evaluate the track and field training of the students in the sample colleges and universities. The evaluation system was used in actual track and field training, 40 students were selected and divided into two groups for the experiment, and the standing long jump, 50-metre run and 800-metre run were assessed before and after the experiment respectively, and the interest of the research subjects in track and field training was tested through questionnaires. Through the comparison of the changes in the performance of track and field training events and the changes in training interest of the sample students before and after the experiment, the role of smart wearable devices on the enhancement of the effect of track and field training is corroborated.

2. The value of smart wearables in athletics training

Athletics, as the foundation of sports programmes, plays an important role in developing students' sports skills, enhancing physical fitness and promoting a healthy lifestyle. Introducing smart wearable devices into track and field training and using the advanced functions and data analysis capabilities of intelligent devices are expected to bring revolutionary changes to track and field training.

2.1. Stimulate interest in track and field training

In track and field training, the introduction of smart wearable devices as a novel form of teaching can greatly stimulate students' interest in participating in track and field sports. These devices usually have fashionable and avant-garde appearance design, which meets the aesthetic demand, thus attracting students to actively participate in track and field activities. In addition, the interactive and intelligent features of smart devices can also bring a more vivid and interesting experience for track and field training, which can further stimulate students' learning interest and motivation.

2.2. Real-time motion data monitoring

Through built-in sensors and algorithms, smart wearable devices are able to monitor and record various data of students in athletics in real time, such as the number of steps, speed, heart rate, calories burned and so on. These data can not only help coaches more accurately understand each student's sports status and fitness level, so as to conduct more targeted guidance and training. At the same time, it also enables students to have a clearer understanding of their own exercise performance, so as to adjust their training programmes and improve their exercise results.

2.3. Enhancing the effectiveness of training practices

Many smart wearable devices have built-in scientific training plans and exercise advice, which are often personalised based on factors such as the user's fitness data, exercise goals, and exercise habits. These scientific designs can effectively enhance the effectiveness of students' track and field training practices and help them achieve better results in a short period of time. At the same time, the smart devices can also provide real-time exercise feedback and suggestions to help students correct wrong movements and postures in a timely manner to further improve their exercise results.

2.4. Expanding the content of athletics teaching

Smart wearable devices are usually equipped with a rich resource reserve function, which can store and download a large number of athletics teaching videos, tutorials and training plans and other materials. These resources can not only be used to supplement and expand the content of classroom teaching, but also help students understand and master the knowledge and skills of athletics more comprehensively. They can also provide students with opportunities for independent learning and training outside the classroom to further improve their athletic abilities and standards.

3. Construction of a track and field training evaluation system based on wearable devices

Based on the function that smart wearable devices can provide real-time data monitoring and feedback on track and field training, this chapter uses the monitoring indexes of smart wearable devices to construct a track and field training evaluation system, which helps track and field coaches and students to understand the training situation and make timely adjustments to the training programme.

3.1. Subjects of study

In the stage of system construction and validation is to take the track and field training class of a university as the research object. The evaluation system constructed by the Delphi method contains numerous indicators, and the data were factor analysed after the system construction was completed. Two research-grade devices, Polar Team2 Pro (worn on the chest) and ActiGraph GTX3+ (worn on the waist), which can guarantee the coverage of most measurable indicators of wearable devices, were selected to collect data from students in the track and field training class.

3.2. Research Methodology

The track and field training assessment system based on wearable devices uses the Delphi method and factor analysis in the construction process, and after completing the construction, it combines the fuzzy comprehensive evaluation method to carry out the application of this assessment system.

3.2.1. Factor analysis. Factor analysis is a method of multivariate statistical analysis that starts from the relevant dependencies within the variables under study and reduces some variables with intricate relationships to a small number of composite factors. Factor analysis breaks down each original variable into two parts: one is composed of a few factors common to all variables, the so-called common factor part. The other part is the factors that each variable has alone, the so-called unique factor part. The main idea of factor analysis is to simplify the data while retaining most of the information in the original data, avoiding the problem of multiple covariance among variables while losing as little of the main information as possible, and making the analysis of the indicator system simpler and more effective.

Given that p indicator $X_1, X_2, \cdots, X_p$ that is correlated with each other is observed for each sample, and a total of n samples are observed, a vector of p indicators (variables) is formed $X = \left(X_1, X_2, \cdots, X_p\right)$.

Assuming that all these variables have been standardised beforehand, the sample mean of each variable is 0 and the variance is 1.

Because of the existence of correlations between variables, it is always theoretically possible to decompose each variable into two parts:

$$X_i = X_i^* + \varepsilon_i \tag{1}$$

where X_i^* is the portion of X_i that is correlated with the other variables and ε_i is the portion of X_i that is uncorrelated with the other variables.

$X_i^* = 0$ if X_i is not correlated with any of the other variables, $X_i = \varepsilon_i$. Conversely, $\varepsilon_i = 0$ if X_i can be represented by a linear combination of the other variables.

Suppose there is more than one common factor governing p variable and there are m and $\left(m \le p\right)$, denoted as $F_1, F_2, \cdots, F_m$, $F_1, F_2, \cdots, F_n$ uncorrelated with each other and variance of 1,

$\varepsilon_1, \varepsilon_2, \cdots, \varepsilon_0$ uncorrelated with each other, and different variances of $\sigma_n, \sigma_{n2}, \cdots, \sigma_{n2}$, respectively. Eq. (2) can be expressed in the following form:

$$\begin{cases} X_1 = a_{11}F_1 + a_{12}F_2 + \cdots + a_{12}F_2 + \varepsilon_1 \\ X_2 = a_{21}F_1 + a_{22}F_2 + \cdots + a_{22}F_2 + \varepsilon_2 \\ \qquad \vdots \\ X_p = a_{p1}F_1 + a_{22}F_2 + \cdots + a_{82}F_2 + \varepsilon_p \end{cases} \tag{2}$$

It is a mathematical model for type R factor analysis. Where a_{ij} denotes the loading coefficient (also known as weight coefficient) of X_i on the common factor F_1, and $\left(\varepsilon_1, \varepsilon_2, \cdots, \varepsilon_p\right)$ is a factor that is not correlated with $\left(F_1, F_2, \cdots, F_n\right)$, known as the special factor (also known as the uniqueness factor).

The mathematical model of type R factor analysis can be represented by a matrix as:

$$\begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_p \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1m} \\ a_{21} & a_{22} & \dots & a_{2m} \\ \vdots & \vdots & \dots & \vdots \\ a_{p1} & a_{p2} & \dots & a_{pm} \end{pmatrix} \begin{pmatrix} F_1 \\ F_2 \\ \vdots \\ F_m \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_p \end{pmatrix} \tag{3}$$

It can thus be abbreviated as:

$$X = AF + \varepsilon \tag{4}$$

3.2.2. Fuzzy integrated evaluation method. The fuzzy comprehensive evaluation method is divided into a one-level model and a multilevel model, which is based on the following principles: firstly, all the factors affecting the target are listed to form a factor set, which is also known as the evaluation indicator. Secondly, the evaluation level is established to form an evaluation set. Each factor in the factor set is fuzzy judged through the evaluation set, and the affiliation degree of each factor in the evaluation set is determined to obtain a fuzzy matrix. Give each factor the corresponding weight, get the weight vector, and finally get the evaluation results. Multilevel modelling is the process of constructing multiple first-level models.

The steps of the fuzzy comprehensive evaluation method are shown below:

1) Construct the factor set. The factor set, also known as the evaluation indicator set, $U = \left\{u_1, u_2, \ldots u_m\right\}$, where u_i is the evaluation indicator, $i = 1, 2, \ldots m$, m is the number of single factors under the same dimension.

2) Constructing the evaluation set. Evaluation set, also known as the set of evaluation results, $V = \left\{v_1, v_2, \ldots, v_n\right\}$, where v_j is the evaluation results, $j = 1, 2, \ldots n$, n is the number of grades of evaluation.

3) Determine the degree of affiliation. The fuzzy vectors $R_i = \left(r_{i1}, r_{i2}, \ldots, r_{im}\right)$, $j = 1, 2, \ldots n$ and r_{ij} are obtained by evaluating the first factor i, indicating that u_i contains the percentage of v_j, and the range of r_{ij} is greater than 0 and less than 1. Thus, the evaluation of the n factors results in a n-row and m-column affiliation matrix R, R, which contains all of the contents obtained by the comprehensive evaluation of the factor set U according to the evaluation set V.

4) Determination of weights. Certain methods are taken to determine the weight vector $W = \left\{w_1, w_2, \ldots, w_n\right\}$, $w_i = \left\{w_{i1}, w_{i2}, \ldots, w_{ij}\right\}$, w_i representing the importance of factor u_i to satisfy the conditions:

$$\sum_{i=1}^{n} w_i = 1, 0 \le w_1 \le 1 \tag{5}$$

w_{ij} indicates the magnitude of the weight of the i nd factor in the j rd rank of the evaluation set.

5) Completing the evaluation. The final comprehensive evaluation result is obtained by multiplying the judgement matrix R with the weights W, and the formula is:

$$B = W \cdot R = \left(b_1, b_2, \ldots, b_m\right) \tag{6}$$

Of these, $b_j = \sum_{i=1}^{n} w_i \cdot r_{ij}$, $j = 1, 2, \ldots, n$.

3.3. Selection of Measurement Indicators

In this study, the Delphi method was used to determine the indicators of the constructed system, and the indicators were screened by combining the average score and coefficient of variation of each indicator. After several rounds of expert questionnaire consultation, the preliminary determination of the track and field training evaluation index system based on smart wearable devices, and the correspondence between each index and the function of wearable devices are shown in Table 1. Athletic training evaluation is divided into two primary indicators: “teacher teaching” and “student learning”. The “/” indicates that the indicator can only be measured by traditional methods, and the wearable device cannot reflect this indicator for the time being. The thresholds for each of the measurable indicators are determined by the visualization score box method, and the values are assigned sequentially. In order to reduce the connection between the indicators, this study used two scoring forms, “average heart rate index” and “heart rate index compliance rate”, according to the experts' opinions, to increase the differentiation of the indicators.

Table 1. The corresponding conditions of various indicators and wearable equipment

Primary indicator	Secondary indicator	Observation point
A1 Student learning	B11 Suitable load strength	Average heart rate index
		The rate of the heart rate curve
		The proportion of MVPA
	B12 Reasonable practice density	Practice density
	B13 Complete course quality	Average heart rate index
		Practice density
	B14 Skills development	/
	B15 Physical development	Average heart rate index
		Practice density
		The proportion of MVPA
	B16 Active input in class	Average heart rate index
		The proportion of MVPA
	B17 Exercise knowledge	/
	B18 Will quality development	/
A2 Teacher teaching	B21 Full utilization time	Practice density
		The proportion of MVPA
		Average heart rate index
		The rate of the heart rate curve
	B22 Protection helps implement	/
	B23 Outstanding teaching goal	/
	B24 Motivate students	The proportion of MVPA
		Average heart rate index
		Practice density
	B25 The demonstration in place	/

	B26 Reasonable content arrangement	Average heart rate index
		Practice density
		The rate of the heart rate curve
	B27 Application of teaching principle	/
	B28 Equipment preparation	/
	B29 Clear teaching steps	/
	B210 Implement the class routine	/
	B211 Discriminate	Heart rate warning
		The heart rate index reaches the standard ratio
	B212 Instrument state	/
	B213 Full care	The heart rate index reaches the standard ratio
	B214 Quality of teaching case	/

3.4. Factor analysis

An exploratory factor analysis is conducted on the initially constructed assessment system. Generally speaking, exploratory factor analysis can determine the number of factors in advance. In this study, two common factors, "teacher teaching" and "student learning", were identified in advance, which were used as the framework for exploratory factor analysis of the assessment system, and the results of KMO and Bartlett's test are shown in Table 2. The KMO value is 0.768, which is moderate and close to good, and the result shows that "Wearable device-based track and field training assessment system" is suitable for factor analysis. The result of Butler's spherical test is p<0.001, which is significant and rejects the hypothesis of correlation matrix unit matrix, indicating that the collected data are suitable for factor analysis.

Table 2. The results of KMO and bartlett

Kaiser-Meyer-Olkin availability quantity	0.768
Bartlett sphericity test approximation card allocation	3125.626
Df	237
Significance	<0.001

The matrix of rotational components after the sieve is shown in Table 3. The principal factor 1 "student learning" affected by B11 to B18 is larger, and the load of each indicator on the principal factor 1 > 0.64, which means that the "student learning" in the track and field training class is large. Other indicators had a great impact on the main factor 2 "teacher teaching", and the factor load was > 0.62. Finally, factor 1 was named "student learning" and factor 2 was named "teacher teaching". Through the explanation of the total variance, the cumulative contribution rate of the two principal components was 71.52%, which met the requirements and had explanatory value for the evaluation system.

Table 3. The rotating composition matrix after the sieve

Index	Composition	
	1	2
B11 Suitable load strength	0.777	0.414
B12 Reasonable practice density	0.684	0.515
B13 Complete course quality	0.667	0.496
B14 Skills development	0.753	0.178

B15 Physical development	0.777	0.541
B16 Active input in class	0.848	0.474
B17 Exercise knowledge	0.642	0.326
B18 Will quality development	0.807	0.352
B21 Full utilization time	0.247	0.772
B22 Protection helps implement	0.191	0.689
B23 Outstanding teaching goal	0.227	0.626
B24 Motivate students	0.342	0.702
B25 The demonstration in place	0.541	0.759
B26 Reasonable content arrangement	0.374	0.624
B27 Application of teaching principle	0.483	0.683
B28 Equipment preparation	0.112	0.719
B29 Clear teaching steps	0.394	0.734
B210 Implement the class routine	0.545	0.625
B211 Discriminate	0.125	0.723
B212 Instrument state	0.357	0.628
B213 Full care	0.222	0.711
B214 Quality of teaching case	0.426	0.809

After the system indicators are determined, the results of the simple table method are used to establish a matrix for each indicator, and the weights of the indicators of the measurement system are reorganized. The measurement system indicators and weights were determined as shown in Table 4. The weights of student learning and teacher teaching in the track and field training assessment indicators are 35.55% and 64.45%, respectively. Among the student learning indicators, B13 quality of course completion (5.85) and B17 mastery of sports knowledge (5.61) had the greatest weight, and among the teacher teaching indicators, B21 making full use of time (7.30) and B22 protection help in place (6.79) had the greatest impact on the track and field training assessment.

Table 4. Measurement system index and weight determination

Primary indicator	Secondary indicator and weigh/%			Observation point and weigh/%		
	Number	Relative	Absolute	Function name	Relative	Absolute
A1 Student learning 35.55	B11	15.36	5.46	Average heart rate index	48.17	2.63
				The rate of the heart rate curve	16.67	0.91
				The proportion of MVPA	35.16	1.92
	B12	11.28	4.01	Practice density	100.00	4.01
	B13	16.45	5.85	Average heart rate index	50.00	2.93
				Practice density	50.00	2.93
	B14	13.60	4.83	/	100.00	4.83
	B15	11.77	4.18	Average heart rate index	43.54	1.82
				Practice density	12.92	0.54
				The proportion of MVPA	43.54	1.82
	B16	9.29	3.30	Average heart rate index	54.24	1.79
				The proportion of MVPA	45.76	1.51
	B17	15.79	5.61	/	100.00	5.61
	B18	6.47	2.30	/	100.00	2.30
A2 Teacher teaching	B21	11.33	7.30	Practice density	38.22	2.79
				The proportion of MVPA	29.45	2.15
				Average heart rate index	18.08	1.32

64.45				The rate of the heart rate curve	14.25	1.04
	B22	10.54	6.79	/	100.00	6.79
	B23	10.30	6.64	/	100.00	6.64
	B24	10.14	6.54	The proportion of MVPA	46.02	3.01
				Average heart rate index	21.10	1.38
				Practice density	32.87	2.15
	B25	9.39	6.05	/	100.00	6.05
	B26	9.24	5.96	Average heart rate index	59.06	3.52
				Practice density	26.01	1.55
				The rate of the heart rate curve	14.93	0.89
	B27	8.23	5.30	/	100.00	5.30
	B28	7.88	5.08	/	100.00	5.08
	B29	5.02	3.24	/	100.00	3.24
	B210	2.49	1.60	/	100.00	1.60
	B211	4.75	3.06	Heart rate warning	59.15	1.81
				The heart rate index reaches the standard ratio	40.85	1.25
	B212	3.04	1.96	/	100.00	1.96
	B213	4.62	2.98	The heart rate index reaches the standard ratio	100.00	2.98
	B214	3.04	1.96	/	100.00	1.96

3.5. Application of the measurement system

Based on the assessment system constructed in this study, the data collected by smart wearable devices and questionnaire data were used to measure and apply the data of the sample colleges and universities' track and field training classes, and the scores of the sample colleges and universities' track and field training assessment are shown in Figure 1. The total score of track and field training in the sample colleges and universities averaged 73.71 points, and the overall performance was fair. The student learning and teacher teaching scores were 71.03 and 75.19 respectively, with higher teacher teaching scores. To a certain extent, it shows that teachers are more serious and responsible in track and field training classes, and their performance is generally good and stable, and it can also be said that the basic professionalism of teachers is generally high, and all of them are able to meet the basic requirements to ensure track and field training classes, while the performance of students in track and field training is slightly deficient. The scores of B18 Development of will quality in students' learning and B213 Comprehensive care in teachers' teaching were both below 60, which means that there is still a need to improve the development of students' will quality and teachers' mastery of students' training in the sample track and field training.

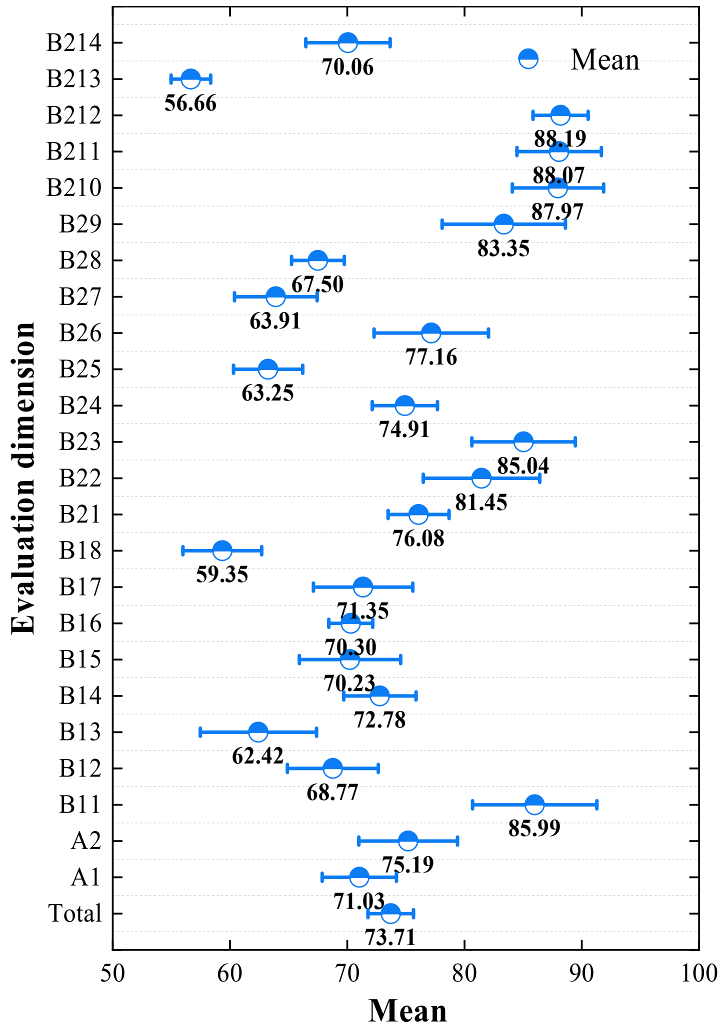

Fig. 1. The evaluation scores of the field training of the university

4. Analysis of athletic performance enhancement in track and field training

According to the track and field training assessment system based on smart wearable devices, it is used in students' track and field training, and a teaching experiment is designed to investigate the influence of real-time feedback data of wearable devices and the assessment system on the improvement of track and field training effect.

4.1. Experimental design

In this paper, 40 students in the track and field training course of a sample university were taught simultaneously in Group A (experimental group) and Group B (control group). The selected experimental subjects were all students at the basic stage to ensure the same level, and Group A was equipped with wearable devices to monitor and analyze the experimental data of the students and used the track and field training evaluation system based on wearable devices to assist the training, while Group B used the traditional training methods. Group B used traditional training methods. Finally, the results of the two groups were compared and analyzed by means of assessment.

Athletic training assessment items include height, weight, standing long jump, 50-meter sprint and 800-meter long run. In addition, a questionnaire survey was conducted before and after the experiment to investigate the students' interest in track and field training from the six aspects of novelty, negativity, concern, exploration, pleasure and positivity, respectively.

4.2. Training design

Smart wearable devices utilize advanced sensors and algorithms to monitor and record students' physiological data in real time, providing coaches and students with more accurate training feedback.Group A utilizes smart wearable devices to monitor students' physiological data such as heart rate, respiratory rate, steps, distance and calories burned in real time. These data can help students and coaches have a clearer understanding of the students' training status and level of recovery. For example, heart rate data can reflect a student's fatigue level and exercise intensity, while the number of steps and distance can measure the amount of exercise and energy consumed. In addition, the data collected by the smart wearable devices are inputted into the track and field training evaluation system to assess the performance of students and teachers in track and field training, so that coaches and students can more accurately understand the status of training and formulate more scientific and reasonable training plans.

4.3. Results and analysis

4.3.1. Analysis of pre-test results. Before the beginning of the experiment to test the level of track and field training of students in group A and group B, the two groups of experimental subjects to independent samples T-test, combined with the chart combination analysis, the comparison of the level of track and field training of students in the two groups before the experiment is shown in Table 5. The data of physical quality test for a total of 40 people in group A and group B before the experiment, in which the data of students' height, weight, standing long jump, 50-meter run and 800-meter run do not have significant differences (P>0.05), which indicates that there is no significant difference in physical quality of the experimental subjects before the experiment. The results of the above data analysis indicate that there is no significant difference between the physical quality of group A and group B before the experiment and the experiment can be carried out.

Table 5. The level of track and field training of two groups students before experiment

Item	Group	Mean	SD	T	P
Height	Group A	173.96	3.14	0.97	0.29
	Group B	174.72	3.33		
Weight	Group A	67.43	4.12	0.49	0.31
	Group B	68.68	3.91		
Fixed jump	Group A	187.98	2.38	0.72	0.42
	Group B	186.43	2.23		
50m run	Group A	11.07	2.13	0.64	0.64
	Group B	10.62	2.22		
800m run	Group A	156.17	3.34	0.95	0.18
	Group B	157.05	3.39		

4.3.2. Pre-test interest analysis. Before the beginning of the experiment, Group A and Group B were issued with “Athletic Training Interest Scale” respectively, and students were asked to fill in the form on the spot and collect it on the spot, and the collected data were subjected to independent samples t-test and statistically analyzed by using combined charts and graphs. The comparison of the two groups of students' interests in track and field training before the experiment is shown in Table 6, and there is no significant difference between Group A and Group B in “novelty, negativity, attention, exploration, enjoyment, and positivity” (P>0.05), so there is no big difference between the students' interests in track and field training before the experiment.

Table 6. The interest of track and field training of two groups students before experiment

Item	Group	Mean	SD	T	P
Novelty	Group A	3.04	1.17	1.46	0.56
	Group B	2.94	1.20		
Negativity	Group A	2.59	0.65	0.69	0.73
	Group B	2.47	0.72		
Attention	Group A	2.66	1.24	0.91	0.62
	Group B	2.72	1.26		
Exploratory	Group A	2.92	1.39	1.16	0.35
	Group B	3.09	1.34		
Pleasure	Group A	3.09	1.47	1.23	0.96
	Group B	3.05	1.54		
Positivity	Group A	2.73	0.63	0.65	0.42
	Group B	2.89	0.68		

4.3.3. Analysis of the results of the post-experimental tests. At the end of the experiment, the track and field training levels of the students in Group A and Group B were tested, and the comparison of the track and field training levels after the experiment is shown in Table 7.The students in Group A, after adopting the smart wearable device and the track and field training evaluation system to assist their training, had better test scores than those of the students in Group B in the standing long jump, the 50-meter run and the 800-meter run, with an improvement of 4.17%, 5.01% and 4.09%, respectively, and all of them showed significant differences at the level of 5%, indicating that the real-time data monitoring and the feedback effect of the track and field training system can improve the students' track and field training effect. 5% level showed significant differences, indicating that the real-time data monitoring of the smart wearable devices and the feedback effect of the assessment system can improve the students' track and field training effect.

Table 7. The level of track and field training after experiment

Item	Group	Mean	SD	T	P
Height	Group A	174.51	3.23	1.09	0.38
	Group B	174.74	3.29		
Weight	Group A	66.34	2.76	0.36	0.22
	Group B	67.67	2.83		
Fixed jump	Group A	196.09	3.09	0.65	0.01
	Group B	188.24	3.38		
50m run	Group A	9.58	2.03	0.57	0.03
	Group B	10.06	2.27		
800m run	Group A	150.49	2.35	0.64	0.02
	Group B	156.64	2.61		

4.3.4. Post-test interest analysis. The comparison of the two groups of students' interests in track and field training after the experiment is shown in Table 8. Before the experiment, there is a significant difference between Group A and Group B in "novelty, negativity, attention, exploration, pleasure, positivity" ($P<0.05$). In terms of negativity, group A was significantly lower than group B, indicating that through the application of smart wearable devices in track and field training, the students in group A were confident in track and field training and were able to positively face new training maneuvers. In addition, the students' learning attention and explorability were effectively improved, indicating that during the training process, the students were able to actively explore and learn about the difficult and important issues of track and field training, which also enhanced their enthusiasm and interest in track and field training from the other side. Therefore, after the end of the experiment in Group A, the students were enthusiastic about track and field training, improved their learning motivation, and promoted the overall development of the students.

Table 8. The interest of track and field training after experiment

Item	Group	Mean	SD	T	P
Novelty	Group A	4.14	0.74	2.63	0.04
	Group B	3.05	0.99		
Negativity	Group A	1.57	0.68	2.67	0.02
	Group B	2.15	0.84		
Attention	Group A	3.34	0.53	3.01	0.01
	Group B	2.86	0.68		
Exploratory	Group A	3.87	0.83	2.86	0.03
	Group B	3.15	1.09		
Pleasure	Group A	4.29	0.58	3.38	0.01
	Group B	3.21	0.89		
Positivity	Group A	3.75	0.62	2.49	0.02
	Group B	2.97	0.81		

5. Conclusion

Smart wearable devices are the products of the combination of modern technology and sports training, and play an increasingly important role in track and field training. Based on the real-time data feedback of smart wearable devices, this project designs the track and field training evaluation system by selecting evaluation indexes. The evaluation system and smart wearable devices are used in the practice of track and field training to explore its role in enhancing the athletic performance and training interest in track and field training.

The track and field training evaluation system constructed in this paper includes 2 primary indicators and 22 secondary indicators and their corresponding observation points of the wearable device data. Through factor analysis, the indicators were divided into two factors: student learning and teacher teaching, and the cumulative contribution rate of the principal components was 71.52%, with the weights of 0.3555 and 0.6445, respectively.The overall score of track and field training of the students in the sample colleges and universities was 73.71, which was in the middle level, with the score of student learning slightly lower than that of teacher teaching.

After track and field training based on smart wearable devices and assessment system, there is a significant difference at 5% level between group A students and group B students in three track and field events, namely standing long jump, 50-meter run and 800-meter run. The athletic performance of track and field training assisted by smart wearable devices was improved by 4.09% to 5.01%. Meanwhile, there was also a significant difference between the two groups of students in the dimensions of training interest ($P<0.05$), indicating that track and field training based on smart wearable devices can stimulate students' interest in track and field training, and improve the enthusiasm and motivation of training.

The introduction of smart wearable devices enables coaches and athletes to obtain and analyze training data in real time, and accurately understand key information such as athletes' physical status, technical execution and physical energy consumption during training. Meanwhile, the track and field training evaluation system based on smart wearable devices also provides teachers and students with the opportunity to evaluate and improve, helping them to understand the training situation and adjust the training program, and promoting the improvement of track and field training effect.

References

[1] Luo, D. (2021). The Application of Computer Technology in Sports Training and Competition. In 2020 International Conference on Applications and Techniques in Cyber Intelligence: Applications and Techniques in Cyber Intelligence (ATCI 2020) (pp. 543-549). Springer International Publishing.

[2] Toto, G. A. (2022). A Systematic Review on Digital Technologies on Sport Science: Didactic of Sport. Formazione & insegnamento, 20(1 Suppl.), 001-012.

[3] Baca, A., Chetouani, A. K., Wallnöfer, E. K., Kornfeind, P., & Exel, J. (2023, September). Integration of Digital Tools in Training and Sports Education. In International Symposium on Computer Science in Sport (pp. 147-153). Singapore: Springer Nature Singapore.

[4] Mali, N. P., & Dey, S. K. (2020). Modern technology and sports performance: An overview. International Journal of Physiology, 5(1), 212-216.

[5] Chen, K., Cao, F., Hao, L., Xiang, M., & Kamruzzaman, M. M. (2022). Application analysis of digital neural network-based data mining method in maximizing the performance of sports training. Revista Brasileira de Medicina do Esporte, 29, e2022_0152.

[6] Sandbakk, Ø. (2020). The role of sport science in the new age of digital sport. International Journal of Sports Physiology and Performance, 15(2), 153-153.

[7] Schlegel, M. U., & Hill, C. (2023). The reach of sports technologies. In 21st Century Sports: How Technologies Will Change Sports in the Digital Age (pp. 105-125). Cham: Springer International Publishing.

[8] Вако, І. І., Григус, І. М., & Нікітенко, О. В. (2023). The use of modern multimedia resources in the practice of sports and physical education. Rehabilitation and Recreation, (14), 258-268.

[9] Kettunen, E., Kari, T., Critchley, W., & Frank, L. (2024). Critical experiences with sport and wellness technology digital coach–differences between young adults and young elderly. Behaviour & Information Technology, 43(12), 3010-3026.

[10] Ahir, K., Govani, K., Gajera, R., & Shah, M. (2020). Application on virtual reality for enhanced education learning, military training and sports. Augmented Human Research, 5, 1-9.

[11] Cardinale, M., & Varley, M. C. (2017). Wearable training-monitoring technology: applications, challenges, and opportunities. International journal of sports physiology and performance, 12(s2), S2-55.

[12] Luczak, T., Burch, R., Lewis, E., Chander, H., & Ball, J. (2020). State-of-the-art review of athletic wearable technology: What 113 strength and conditioning coaches and athletic trainers from the USA said about technology in sports. International Journal of Sports Science & Coaching, 15(1), 26-40.

[13] Crang, Z. L., Duthie, G., Cole, M. H., Weakley, J., Hewitt, A., & Johnston, R. D. (2021). The validity and reliability of wearable microtechnology for intermittent team sports: A systematic review. Sports Medicine, 51, 549-565.

[14] Seshadri, D. R., Drummond, C., Craker, J., Rowbottom, J. R., & Voos, J. E. (2017). Wearable devices for sports: new integrated technologies allow coaches, physicians, and trainers to better understand the physical demands of athletes in real time. IEEE pulse, 8(1), 38-43.

[15] Migliaccio, G. M., Padulo, J., & Russo, L. (2024). The Impact of Wearable Technologies on Marginal Gains in Sports Performance: An Integrative Overview on Advances in Sports, Exercise, and Health. Applied Sciences, 14(15), 6649.

[16] Jing, R., Wang, Z., & Suo, P. (2024). Optimization of track and field training methods based on SSA-BP and its effect on athletes' explosive power. Heliyon, 10(3).

[17] Foster, C., Rodriguez-Marroyo, J. A., & De Koning, J. J. (2017). Monitoring training loads: the past, the present, and the future. International journal of sports physiology and performance, 12(s2), S2-2.

[18] Appelbaum, L. G., & Erickson, G. (2018). Sports vision training: A review of the state-of-the-art in digital training techniques. International Review of Sport and Exercise Psychology, 11(1), 160-189.

[19] Hadlow, S. M., Panchuk, D., Mann, D. L., Portus, M. R., & Abernethy, B. (2018). Modified perceptual training in sport: a new classification framework. Journal of Science and Medicine in Sport, 21(9), 950-958.

[20] Ma, B., Nie, S., Ji, M., & Song, J. (2020). Research and Analysis of Sports Training Real - Time Monitoring System Based on Mobile Artificial Intelligence Terminal. Wireless Communications and Mobile Computing, 2020(1), 8879616.

[21] Mao, Y., Yue, W., Zhao, T., Shen, M., Liu, B., & Chen, S. (2020). A self-powered biosensor for monitoring maximal lactate steady state in sport training. Biosensors, 10(7), 75.

[22] Cannavò, A., Pratticò, F. G., Ministeri, G., & Lamberti, F. (2018, February). A movement analysis system based on immersive virtual reality and wearable technology for sport training. In Proceedings of the 4th international conference on virtual reality (pp. 26-31).

[23] Macadam, P., Cronin, J. B., & Simperingham, K. D. (2017). The effects of wearable resistance training on metabolic, kinematic and kinetic variables during walking, running, sprint running and jumping: A systematic review. Sports Medicine, 47, 887-906.

[24] Boltayevna, Z. F. (2022). Review of Facilities and Technologies During Training in Track and Field. Central Asian Journal of Medical and Natural Science, 3(5), 290-293.

[25] Yuan, Y. (2024). Exploration of Teaching and Training Methods for Track and Field Sports in School Physical Education. Journal of Human Movement Science, 5(2), 9-15.

[26] Zhao, Y. (2017, February). Analysis on special training methods of track and field sprint. In 2016 7th International Conference on Education, Management, Computer and Medicine (EMCM 2016). Atlantis Press.