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Article

Biological analysis method based on the relationship between athlete's PSI rhythm and sports injury

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Abstract: Biorhythm is the law of cyclical changes in individual life activity characteristics as time changes. Biorhythm is an internal law of a biological organism, which comes from the changes that a biological organism is affected by changes in the external environment during natural activities, so its change law is similar to the cycle of the natural environment. Biological rhythms play an important role in mediating human body functions, vital activities, body temperature and other physiological reactions. The balance and stability of biological rhythms can ensure the healthy life activities of the human body. Disrupting the balance of biological rhythms may cause various kinds of human body. In this paper, the research of biological analysis method based on the relationship between athlete's PSI (Physical, Sensitive, Intellectual) rhythm and sports injury is mainly introduced, and ideas and directions are intended to be provided for analyzing the relationship between athlete's physical strength, emotion, intelligence and sports injury. This paper proposes a research strategy based on the biological analysis method of athlete's PSI rhythm and sports injury, including measurement of biological rhythm, literature retrieval method, expert interview method, questionnaire survey method, clustering algorithm-based biological analysis method. A research experiment on the biological analysis method of the relationship between PSI rhythm and sports injury is conducted. The experimental results of this paper indicated that most sports injuries of athletes occur in the critical period of PSI rhythm, with an average incidence of 70.14%. Athletes' training and competition can be avoided in this critical period as much as possible.

Keywords: sports players; human biological rhythm; sports injury; biological analysis

1. Introduction

At the beginning of this century, German doctor Ferris and Austrian psychologist Swaboda discovered through long-term clinical observation that the physical cycle of human biological rhythm is 23 days and the emotional cycle is 28 days. After that, Terqier of Austria, after studying the examination results of many college and middle school students, found that the intelligence cycle is 33 days. The changes in physical strength, mood and intelligence are sinusoidal, showing a periodicity of "high tide-critical day-low tide" over time. This law is the human biological rhythm, also known as the human biological three rhythms, namely the physical rhythm, the emotional rhythm, and the intellectual rhythm. It is also called PSI (Physical, Sensitive, Intellectual) rhythm, which is the abbreviation of physical, sensitive, and intellectual. When the three rhythms of the human body are running during the climax period, they show energy, quick thinking, optimistic mood, strong memory and understanding. On the contrary, the three rhythms functioning on critical days or low periods can be characterized by decreased endurance, low mood, slow reaction time, forgetfulness and distraction.

Sports injuries are anatomical damages or physiological disorders that occur in human tissues or organs during sports. Their occurrence is closely related to sports techniques, sports programs, sports environments and so on, and occur mainly in the human locomotor system, including the vascular and nervous systems, which are one of the key components of sports medicine. Sports injuries can be divided into new and old injuries according to time; acute and chronic injuries (including strain and old injuries) according to the course of the disease; open and closed injuries according to the nature of the injury, of which closed injuries can be divided into mild, moderate and severe injuries. For athletes who take professional sports as their profession, it is very important to understand their biological rhythms and to study and analyze the relationship between athletes' biological rhythms and sports injuries. To a certain extent, it can avoid the occurrence of sports injuries caused by training and competition.

Yang et al. [1] believed that ST8SIA2 and NCAM1 were functionally related genes that formed polysialic acid (PSA)-nerve cell adhesion molecule (NCAM) complexes in the suprachiasmatic nucleus (SCN), the regulatory site of circadian rhythms. He also explored the relationship between ST8SIA2 and NCAM1 and the circadian and seasonal rhythms of human behavior. The experiment selected 261 healthy Korean adults as subjects. They did not have any clinically obvious history of mental illness. Controlled trials were circadian rhythms and seasonal changes in mood and behavior (seasonal), which were measured by the morning comprehensive scale and seasonal pattern assessment questionnaire. Yang et al. [1] analyzed 34 single nucleotide polymorphisms (SNPs) in the ST8SIA2 region and 15 SNPs in NCAM1, and apparently significant correlations with seasons and circadian rhythms were observed in 21 variants of the two genes. Liem and Moser [2] believed that biological rhythms were the universal principles of time organization in nature. The experiment could not establish a central timer, but they found a central oscillator to coordinate the experiment. The experiment described the spectrum and characteristics of biological rhythms and timers, and discussed endogenous and exogenous rhythms. The dynamic interaction of biological rhythms is important in the initiation of the healing and regeneration process of the human body [2]. Oppewal and Hilgenkamp [3] proposed a physical fitness test that could be applied to assessing the physical fitness of adolescents. It could help to improve, adapt and evaluate sports injury prevention measures and provide reference values.

The innovations of this paper include the following: (1) proposing a biological analysis method based on clustering algorithm; (2) designing a biological analysis algorithm flow; (3) designing a biological analysis system.

2. Strategy of biological analysis method based on the relationship between athlete's PSI rhythm and sports injury

2.1. Biorhythm

(1) Overview of biological rhythms

Biologists believe that the establishment of biological rhythms is based on cortical dynamic stereotypes. According to the principle of conditioned reflexes, various conditioned reflexes have been established in the cerebral cortex, which form a "dynamic stereotype" after repeated occurrences, that is, the former reflex can easily or even automatically cause the latter reflex [4].

The formation of the human body's day-cycle rhythms is first affected by the external environment, mainly by changes in circadian rhythms caused by the rotation of the earth in nature, that is, extrinsic biological rhythms. Second, the suprachiasmatic nucleus and other centers are sensitive to the light-dark cycle and produce internal biological rhythms synchronized with light-dark changes for approximately 24 h [5].

Human psychological rhythms are closely related to human physiology, which is controlled by the circadian clock of the brain. The human circadian clock mainly consists of the hypothalamus, suprachiasmatic nucleus, pineal gland, pituitary gland, and adrenal system, with a series of neural and endocrine pathways connecting between the stimulated glands [6].

(2) Measurement of biological rhythm

1) Morning-night self-measurement table: it is composed of 19 items, and the score varies from 16 to 86 points. There is a tendency to pre or post sleep when evaluating sleep status. According to the score, the survey subjects can be divided into 3 categories: night type: score range of 16–49 points; middle type: score range of 50–62 points; morning type: score range of 63–86 points [7,8].
2) Formalized sleep questionnaire: the content of the questionnaire survey includes sociodemographic characteristics, sleep characteristics and the use of psychophysical substances [9].
3) Epworth Sleepiness Scale (ESS): this scale involves a total of 8 questions, including the level of sleepiness under different conditions during the day, such as meetings, rides, and studies. A total of four scales (0–3) are used, with higher scores being associated with higher levels of drowsiness [10].
4) The Composite Scale of Morningness (CSM) [11].
5) Munich chrono type questionnaire [12].

Each measurement tool has a specific design purpose and ease of use. In this paper, we chose to take measurements at a fixed time (8 am every morning and evening) and collect physiological data (heart rate, sleep quality, activity level) using wearable devices that can provide real-time and continuous data. Helps determine the physical and mental state of a given point in time.

2.2. Method for research

(1) Document retrieval method

In order to understand and study the relationship between athletes and sports injuries based on PSI rhythm, a set of keywords directly related to the research topic was first identified. The key words of this paper include "biorhythm", "sports injury" and "bioanalysis". The main sources of literature are Shuxiu, Baidu Academic, SpringerLink, CNKI and other platforms. Search and retrieve keywords. In order to optimize search results, specific search filtering conditions (date range, language restrictions, document type) are set, and then relevant literature is consulted for careful summary and analysis [13]. In order to cover a wider range of research and avoid missing important literature, keywords also include synonyms, synonyms, and broad and narrow terms. When searching, Boolean operators ("AND", "OR") are used to combine keywords for more precise retrieval.

(2) Expert interview method

According to the research direction of this paper, the relationship between athletes' PSI rhythm and sports injury is analyzed and discussed through interviews with senior coaches, experts and scholars in related fields. The list of experts to be interviewed was determined and invitations were sent according to their expertise and research area, which clarified the purpose of the study, the expected length of the interview, and the role of the expert in the study. Take their advice seriously. This can provide a multi-angle perspective and provide a more realistic basis for the research of this paper [14]. Before each interview, the interview outline and required materials should be fully prepared to ensure the smooth conduct of the interview to achieve the expected purpose. The main contents of the interview include the occurrence and causes of sports injuries, as well as experts' views on biorhythm and sports injuries, so as to provide more adequate guarantee for the analysis and research based on the biological relationship between PSI rhythm and sports injuries [15]. Design open-ended questions based on the content: 1) Describe how you understand the impact of PSI rhythm on athlete performance. 2) How do you think fluctuations in PSI rhythm are associated with the risk of sports injuries? 3) Do you know of any actual cases of correlation between PSI rhythm and sports injuries in athletes? 4) In your experience, what is the most effective way to prevent sports injuries? gain expert insights. The interviews were conducted in a semi-structured manner, ensuring sufficient flexibility to explore new ideas while maintaining consistency around the research topic. All discussions during the interview were recorded and recorded in detail. After the interview, the interview content was transcribed into text, and the data was encoded to extract key information about the relationship between PSI rhythm and sports injury and identify key concepts and themes. This process involves breaking the conversation down into individual statements or ideas and grouping them into relevant topic categories.

(3) Questionnaire survey method

Questionnaires were distributed face to face to all types of athletes. The questionnaire mainly focuses on the occurrence and causes of sports injuries, as well as the relationship between athletes' own biological rhythm and competition and training performance ((1) incidence of sports injury; (2) time period; (3) injury site; (4) training intensity and frequency; (5) PSI rhythm perception). To ensure the comprehensibility and logic of the questionnaire, a pre-test was conducted with a small group of athletes filling out the questionnaire and providing feedback. According to the results of the pre-test, the wording of some questions and the structure of the questionnaire were adjusted. The sample was representative of different sports, ages, genders and levels of competition. The calculation of the sample size takes into account the expected response rate and expected effect size, as well as the required confidence level and statistical power. Track the response rate after sending the questionnaire, and make reminders when necessary to ensure that an adequate amount of data is collected. The collected data is initially reviewed to screen out incomplete or unusual responses. After data collection, SPSS 17.0 statistical software [16] was used to conduct a series of analyses on the data: Cronbach's alpha value was calculated to evaluate the internal consistency of each part of the questionnaire. Cronbach's alpha values above 0.7 are generally considered acceptable, and higher values imply better questionnaire reliability. Frequency distribution, mean and standard deviation are used to describe the basic characteristics of the data.

2.3. Biological analysis method based on clustering algorithm

(1) Data types in cluster analysis

Numerical variables are commonly used analysis objects for cluster analysis. However, in today's era of rapid increase in data volume, non-numerical data can also be seen everywhere in data mining. The objects generally have the following data types: interval scaled variables, binary variables, symbolic variables, ordinal variables, proportional scale variables, mixed variables [17].

1) Interval scaled variables

Interval scale variables use dissimilarity or similarity to measure the dissimilarity between different classes and the similarity between objects in the same class. The selection of attribute units is an important factor that affects the clustering results, so it is very necessary to standardize the data before clustering [18]. Given a data set of *n* objects with *p* attributes, the original unit value is converted to unitless value.

Calculate the average absolute error, where represents the value of the *i*-th object on the attribute *p*, and is the average:

$$S_p = \frac{1}{n}\sum_{i=1}^{n}\left|x_{ip} - m_p\right| \tag{1}$$

$$m_p = \frac{1}{n}\sum_{i=1}^{n} x_{ip} \tag{2}$$

Calculate standardized measure Z_p:

$$Z_p = \frac{x_{ip} - m_p}{S_p} \tag{3}$$

After the data set is standardized, the degree of dissimilarity can be calculated [19]. Distance is the most commonly used method to measure the degree of dissimilarity between objects. Let $x_i = (x_{i1}, x_{i2}, \dots, x_{ip}), x_j = (x_{j1}, x_{j2}, \dots, x_{jp})$ be two data objects of *p* dimension. There are the following three distance function formulas, in order of Euclidean distance, Manhattan distance, Minkowski distance:

$$D(x_i - x_j) = \left\|x_i - x_j\right\| = \sqrt{\sum_{k=1}^{p}\left(x_{ik} - x_{jk}\right)^2} \tag{4}$$

$$D(x_i - x_j) = \sum_{k=1}^{p}\left|x_{ik} - x_{jk}\right| \tag{5}$$

$$D_m(x_i - x_j) = \left[\sum_{k=1}^{p}\left(x_{ik} - x_{jk}\right)^m\right]^{1/m} \tag{6}$$

2) Binary variable

A binary variable has only two states. For example, it is supposed that there are and only two states for a product quality evaluation: qualified or unqualified. Qualified is represented by 1, and unqualified is represented by 0. Binary variables are symmetrical and asymmetrical. Symmetry means that the content weights represented by 0 and 1 are the same; asymmetry means that the content weights represented by 0 and 1 are not the same [20]. Symmetrical binary variables, whose dissimilarity is constant, are measured by a simple matching coefficient; for asymmetric binary variables, their dissimilarity is not constant, which is measured by Jaccard coefficient [21]. Let $x_i = (x_{i1}, x_{i2}, \dots, x_{ip}), x_j = (x_{j1}, x_{j2}, \dots, x_{jp})$ be two data objects of *p*-dimension; the number of attributes whose attribute value is 1 in the two objects is *q*; the number of attributes whose attribute value is 1 in x_i and 0 in $x_j$is *r*; the number of attributes with 0 in x_i and 1 in x_j is *s*; the number of attributes with 0 in both objects is *t* [22,23].

The simple matching coefficient is defined as:

$$d(x_i, x_j) = \frac{r + s}{q + r + s + t} \tag{7}$$

The Jaccard coefficient is defined as:

$$d(x_i, x_j) = \frac{r + s}{q + r + s} \tag{8}$$

3) Symbolic variable

Symbolic variables can have more than two state values, which is an extension of binary variables. The order between states can be exchanged arbitrarily and state values cannot be compared [24]. For symbolic variables, the degree of dissimilarity between object A and object A is defined as:

$$d(x_i, x_j) = \frac{p - m}{p} \tag{9}$$

4) Ordinal variable

A discrete sequence variable is similar to a symbolic variable, except that the states of the sequence variable are arranged in a certain order. A continuous sequence variable focuses on its relative position rather than the actual value. A sequence variable can be mapped to rank [25]. Assuming that the variable f is a set of sequence variables used to describe n objects, the value of the sequence variable is normalized and mapped to the range [0–1], which can ensure that the weight of each variable is the same:

$$z_{if} = \frac{r_{if} - 1}{M_f - 1} \tag{10}$$

5) Proportional scale variable

The proportional numerical variable is defined as a variable that takes a positive measurement value on a non-linear scale, such as the exponential ratio listed below:

$$Ae^{Bt}/Ae^{-Bt} \tag{11}$$

6) Mixed variables

Without distinguishing data types, cluster analysis is performed as a whole. First, all data is preprocessed into a unified type, and then the dissimilarity is calculated [26]. For data sets to be clustered containing *p* different types, the degree of dissimilarity between object *i* and object *j* can be defined as:

$$d(i,j) = \frac{\sum_{f=1}^{p} \phi_{ij}^{(f)} d_{ij}^{(f)}}{\sum_{f=1}^{p} \phi_{ij}^{(f)}} \quad (12)$$

(2) Clustering criterion selection method

1) Heuristic approach: for a specific dataset, a dissimilarity measure is defined and then clustering is performed based on the nearest neighbour principle [27].

2) Objective function approach: the objective function transforms the clustering process into a problem of finding the optimal solution of the objective function [28]. There is the following formula:

$$J = \sum_{j=1}^{c} \sum_{S_j} \left\| x - m_j \right\|^2 \quad (13)$$

$$m_j = \frac{1}{N_j} \sum_{S_j} x \quad (14)$$

The method part of this article uses the above method to study the biological analysis method based on the relationship between athlete's PSI rhythm and sports injury. **Figure 1** displays the specific process.

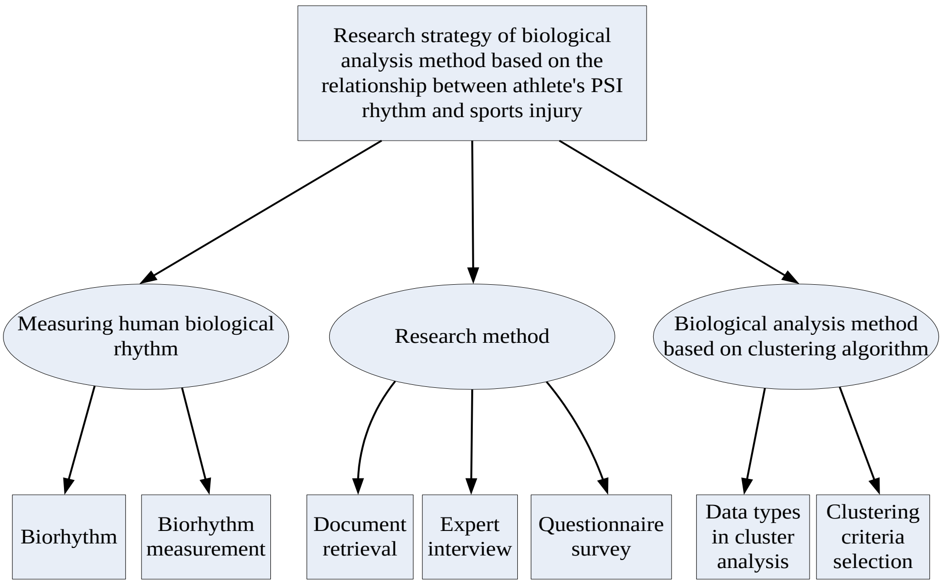

Figure 1. Part of the technical flow chart of this method.

3. Experiment on biological analysis method based on the relationship between athlete's PSI rhythm and sports injury

3.1. Design bioanalysis algorithm flow

(1) Read in all the data in the data set.

(2) Use prim's algorithm to remove outliers in the data set.

(3) Calculate the initial cluster centers according to the breadth-first algorithm.

(4) According to the average value of the data in the cluster, assign data points to the most similar cluster.

(5) Update the average value in the cluster.

(6) Until the standard measure function starts to converge.

3.2. Bioanalysis system design

The entry class of the program is responsible for constructing the display interface, responding to interface events, loading initialization data, calling the clustering algorithm, and displaying the result graph.

(1) Main method: the entry method of the Java application. First call the construction method, initialize the software window, and then start the Java Swing process.

(2) BiocasGui method: the construction method is responsible for initializing the system interface, so the layout of the interface mainly involves Java Swing technology, which is relatively simple.

(3) ActionPerform method: monitors and responds to interface events. The following takes the HCL algorithm in the running menu as an example to illustrate the execution process of this method. First get the command string of the event. If it matches the set value, initialize the HCL algorithm and pop up the parameter setting dialog box.

(4) LoadData method: load the original gene expression data file. This method reads the specified data file according to the row and column offset, and saves the read data into the global data structure Dataset, and at the same time visualizes the gene expression data in the main window.

3.3. System test run

(1) Unit test

This system uses JUnit to perform white-box testing of Java unit code, which can separate business logic code from test code, make the program structure clearer and improve readability.

(2) Integration test

Integration testing is a systematic technique for testing and assembling software. Testing is performed while assembling modules according to design requirements. The main goal is to discover problems related to interfaces. Some modules of the system are combined to test to make the connection between each module correct. The tested units are assembled into a system in a certain order and tests are conducted at the same time. The focus of integration testing is the communication and coordination between modules. The issues that should be considered in integration testing are:

1) Each module is organized together, whether the data transfer between each other is correct, whether there is any loss or mismatch.
2) What effect does the side effect of a module's function implementation have on other modules?
3) Whether the system's global data organization is appropriate and whether there is conflict.
4) Whether the calculation error accumulation of a single module is effectively controlled.
5) Whether the various modules can be organized to meet the requirements specified in the requirements analysis.

From the perspective of the final realization, whether the system requirements analysis itself is complete and whether the realization of each function is compatible and consistent. So far, the testing phase of the system is complete.

(3) Operation process

1) Run the system in eclipse, or double-click the released BioCAS.jar file, the main interface of the system will pop up.
2) Select the "File-Load-Gene Expression Data" menu in turn, and select the data file to be clustered in the file selector window.
3) After importing the original data, display the tree directory, select the "original data" node, the box diagram of the original data is displayed in the scroll panel on the right, and the depth of the color indicates the magnitude of the gene expression value.
4) Before running the clustering algorithm, you need to normalize the original data. Select the "Preprocessing-Preprocessing Data" menu to pop up the data preprocessing selection window.
5) Run the clustering algorithm, and the parameter setting window will pop up. Set the number of clusters, the number of iterations, and the similarity distance.
6) After the algorithm runs, the clustering results are obtained. Click on the cluster node on one side, and the genes in the line box on the other side belong to the same cluster and have similar or identical expression patterns.
7) Click the cluster node, and click the "Gene Expression Profile" tab in the scroll panel on the right to display the expression profile of each gene in the corresponding cluster. It can be seen that genes belonging to the same cluster have similar fluctuation curves.

This part of the experiment proposes that the above steps are used to construct a biological analysis system based on the relationship between the athlete's PSI rhythm and sports injury. **Table 1** shows the specific process.

Table 1. Experimental steps in this article.

Research experiment on biological analysis method based on the relationship between athlete's PSI rhythm and sports injury		
3.1 Design bioanalysis algorithm flow	1	Read all the data in the data set
	2	Use Prim's algorithm to remove outliers in the data set
	3	Calculate the initial cluster centers according to the breadth first algorithm
	4	According to the average of the data in the cluster, assign the data point to the most similar cluster
	5	Update the average value in the cluster
	6	Until the standard measure function starts to converge
3.2 Bioanalysis system design	1	Main method
	2	BiocasGui method
	3	ActionPerform method
	4	LoadData method
3.3 System test run	1	Unit test
	2	Integration testing
	3	Run process

4. Biological analysis method based on the relationship between athlete's PSI rhythm and sports injury

Sports training or routine fitness exercises must be based on the athlete's biological rhythms, including physical rhythms, emotional rhythms, and intellectual rhythms, in order to achieve synchronized and coordinated development as much as possible. This is not only conducive to athletes to achieve better results, but also can effectively avoid sports injuries. Scientific sports training based on the athlete's PSI biological rhythm can improve training efficiency and maximize the athlete's potential. The amount of sports training scientifically and reasonably is arranged to reduce the occurrence of sports injuries during sports training.

4.1. Relevant results of questionnaire survey-expert interviews

(1) The subjects of the questionnaire in this study are athletes engaged in various sports. A total of 240 basketball players, football players, volleyball players, track and field athletes, swimmers, and weightlifters are selected as the subjects of the questionnaire. **Table 2** and **Figure 2** display the exact distribution.

Table 2. Distribution of survey respondents.

Athlete category	Total number of athletes	Number of men	Number of women
Basketball players	51	41	10
Football players	33	27	6
Volleyball players	36	12	24
Track athletes	47	25	22
Swimmers	34	16	18
Weightlifters	39	23	16

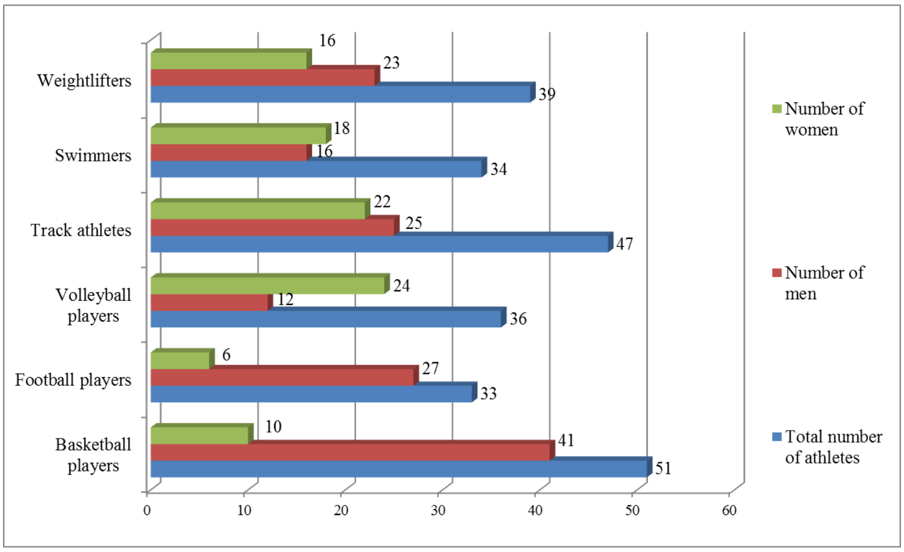

Figure 2. Distribution of survey respondents.

From **Figure 2**, it can be seen that there is a small gap between the total number of athletes in each category. The gap between the number of male and female selections is also smaller, except for basketball players and soccer players. This makes the conclusion of the experiment more convincing.

(2) The subject of expert interviews in this research are senior coaches and related experts engaged in sports teaching and training. A total of 36 experts in basketball, football, volleyball, track, swimming, and weightlifting are also selected for interviews. **Table 3** and **Figure 3** show the specific distribution.

Table 3. Distribution of interviewees.

Distribution of experts	Number of experts	Percentage
Basketball	11	30.56%
Football	7	19.44%
Volleyball	4	11.11%
Track	9	25.00%
Swimming	3	8.33%
Weightlifting	2	5.56%

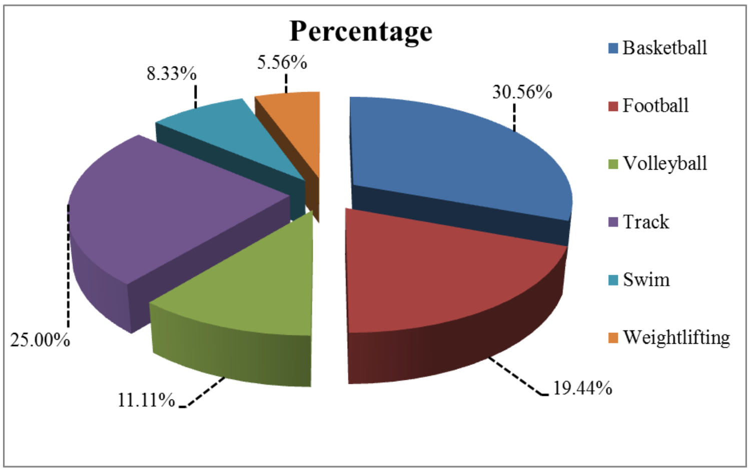

Figure 3. Distribution of interviewees.

Most of the experts interviewed in this article are in ball sports, followed by track and field sports. Few experts are invited in swimming and weightlifting. Compared with other sports, ball games and track and field sports are more popular. In these two sports, more experts are selected for interviews to learn more about the opinions and suggestions of relevant experts.

(3) The number of athletes' sports injuries in the questionnaire is investigated, and the relevant results are counted and organized. **Table 4** and **Figure 4** show the results.

It can be got in the **Table 4** and **Figure 4** that athletes only get injured once or twice, and the number of athletes who have only one or two injuries has generally decreased with the increase of the average service life. Football players have the most sports injuries three to five times; volleyball players have the most sports injuries six to eight times; track athletes have the most sports injuries three to five times; swimmers have three to five sports injuries. The largest number of weightlifters, and the largest number of weightlifters with six to eight sports injuries.

Table 4. Occurrence of sports injuries.

Athlete category	Average years in service	Once or twice	Three to five times	Six to eight times	Eight to ten times	Above ten times
Basketball players	6	1	17	26	5	2
Football players	8	1	13	10	6	3
Volleyball players	2	4	9	15	7	1
Track athletes	5	1	21	19	4	2
Swimmers	4	5	16	9	3	1
Weightlifters	3	3	12	18	2	4

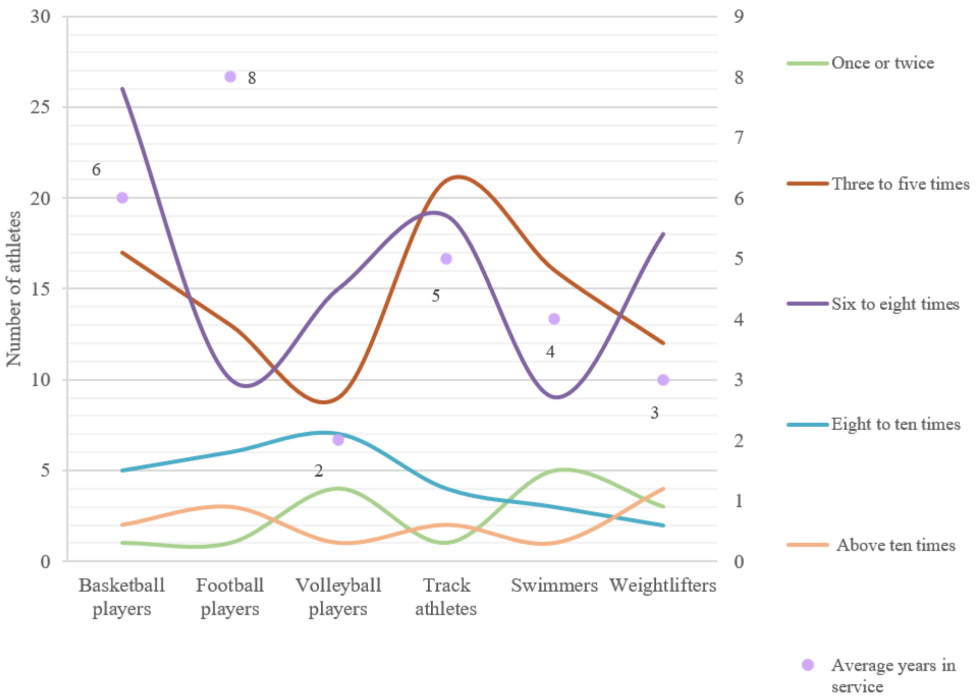

Figure 4. Occurrence of sports injury.

(4) There are many types and forms of sports injuries like diseases. This article divides athletes' sports injuries into categories: bruises, nosebleeds, sprains, contusions, concussions, dislocations, and fractures. The types of athletes' sports injuries are investigated, and **Table 5** and **Figure 5** show the specific conditions.

Table 5. Types of sports injuries in athletes.

Types	Number of athletes	Percentage
Bruises	185	77.08%
Nosebleeds	159	66.25%
Sprains	221	92.08%
Contusions	147	61.25%
Concussions	82	34.17%
Dislocations	124	51.67%
Fractures	133	55.42%

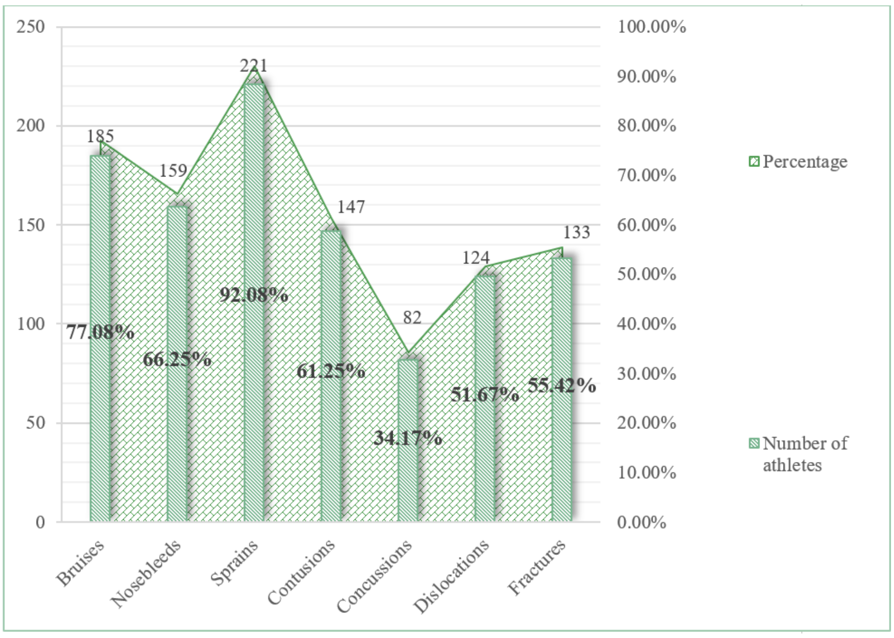

Figure 5. Types of sports injuries in athletes.

Athletes who develop sports injuries during training competitions do not have a single type of sports injury and are unevenly distributed. Among them, sprains accounted for the largest number of athletes, accounting for 92.08% of the total number of athletes who received the questionnaire; followed by abrasions, accounting for 77.08% of the total number of people who received the questionnaire; the third was epistaxis, accounting for 66.25%; the fourth was contusions accounted for 61.25% of the total; fractures accounted for the fifth place, accounting for 55.42%; the sixth was dislocation, accounting for 51.67%; the lowest proportion of sports injuries was concussion, accounting for 34.17%. It can be found that sports injuries frequently occur in athletes' daily training and competition. The relationship between athletes' PSI rhythm and sports injuries, which can help athletes better protect their bodies, needs to be studied.

(5) 20 sports experts and scholars are invited to qualitatively assess the content of the questionnaire. Four main aspects of the questionnaire are assessed, structure, content, logic and design. The specifics of the validity of the statistical questionnaire are plotted in **Table 6** and **Figure 6**.

As can be seen in **Figure 6** and **Table 6**, the experts and scholars who participate in the evaluation are positive about the design, structure, logic and content of the questionnaire. Therefore, the validity of this questionnaire can be considered high.

Table 6. Questionnaire validity test.

Evaluation standard	Very reasonable	Reasonable	Basically reasonable	Not reasonable	Not reasonable at all
Questionnaire structure	7	9	2	2	0
Questionnaire content	5	10	3	1	1
Questionnaire logic	4	7	6	2	1
Questionnaire design	6	11	2	1	0

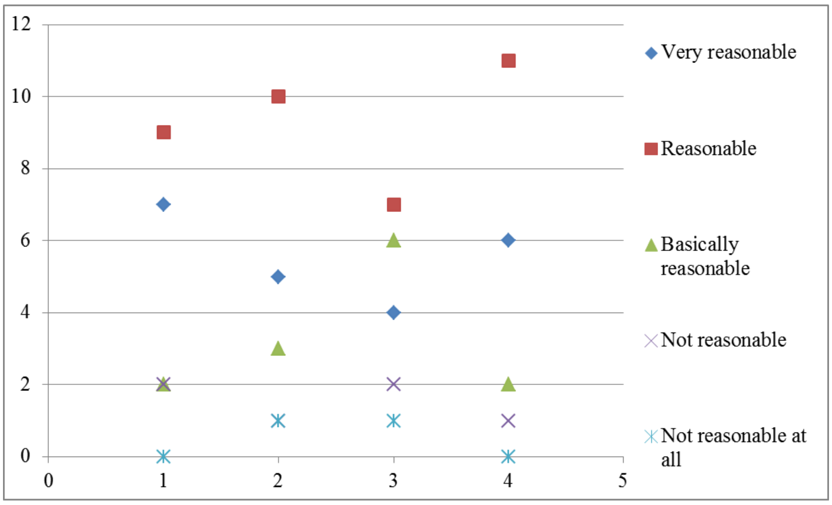

Figure 6. Questionnaire validity test.

(6) The results of the questionnaire are further analyzed and organized in this paper using SPSS 17.0 software. **Table 7** shows the test results.

Table 7. Questionnaire reliability test results.

	Questionnaire structure	Questionnaire content	Questionnaire logic	Questionnaire design
Correlation coefficient (α)	0.971	0.944	0.965	0.932

After calculating the data in **Table 7**, the average value of the questionnaire reliability correlation coefficient α can be obtained as 0.953, which indicates that the reliability value of the questionnaire is relatively high and the questionnaire's survey content is relatively true and reliable.

4.2. Relationship between athletes' PSI rhythm and sports injury

By calculating the biological rhythm of the statistical results of the questionnaire and analyzing the number of people with sports injuries using the above biological analysis method, it is concluded that the athlete's PSI rhythm, namely the physical rhythm, emotional rhythm, and intellectual rhythm, is closely related to sports injury. The different periods of human biological rhythm are related to the occurrence of sports injuries. **Table 8** and **Figure 7** show the specific situations.

Table 8. PSI rhythm and sports injury.

	Climax		Critical period		Low tide period	
	Number of athletes	Incidence rate (%)	Number of athletes	Incidence rate (%)	Number of athletes	Incidence rate (%)
Physical rhythm	31	12.92%	186	77.50%	68	28.33%
Emotional rhythm	24	10.00%	167	69.58%	72	30.00%
Intellectual rhythm	19	7.92%	152	63.33%	53	22.08%

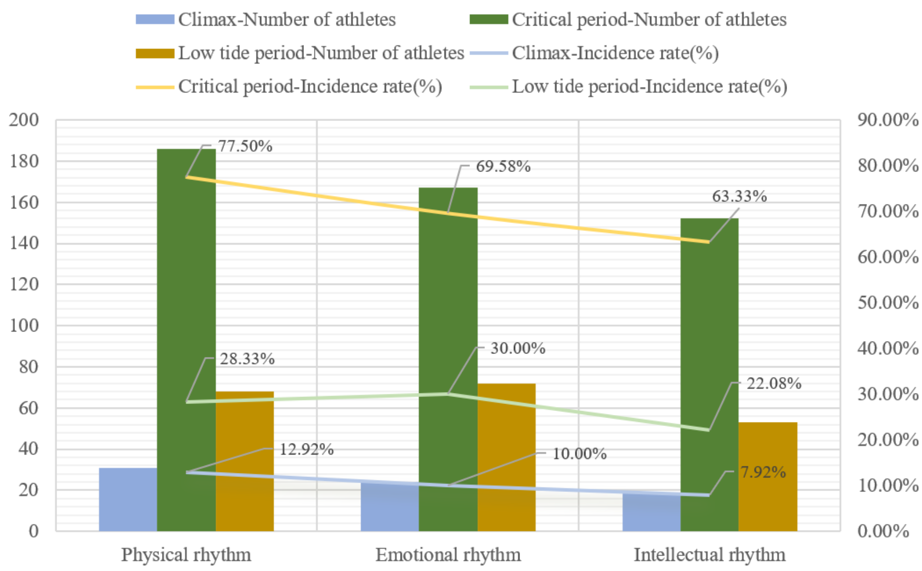

Figure 7. PSI rhythm and sports injury.

It can be found in **Table 8** and **Figure 7** that most sports injuries of athletes occur in the critical period of biological rhythms, with an average incidence of 70.14%, of which the incidence of physical rhythm is 77.5%, the incidence of emotional rhythm is 69.58%, and the incidence of intellectual rhythm is 63.33%; the average incidence of sports injuries during the low tide of the biological rhythm is 26.80%; the frequency of sports injuries occurring during the high tide of the biological rhythm is the smallest, with an average of 10.28%.

Table 9. Differences in PSI rhythm and sports injuries among athletes.

Dimension	Physical rhythm	Emotional rhythm	Intellectual rhythm
Sport			
Soccer	Peak: 10% injury rate	Peak: 8% injury rate	Peak: 5% injury rate
Basketball	Peak: 12% injury rate	Peak: 10% injury rate	Peak: 7% injury rate
Gender			
Male	Peak: 11% injury rate	Peak: 9% injury rate	Peak: 6% injury rate
Female	Peak: 9% injury rate	Peak: 7% injury rate	Peak: 4% injury rate
Age group			
Youth	Peak: 8% injury rate	Peak: 6% injury rate	Peak: 3% injury rate
Adult	Peak: 12% injury rate	Peak: 10% injury rate	Peak: 7% injury rate
Senior	Peak: 15% injury rate	Peak: 13% injury rate	Peak: 10% injury rate
Level			
Amateur	Peak: 9% injury rate	Peak: 7% injury rate	Peak: 4% injury rate
Semi-Pro	Peak: 11% injury rate	Peak: 9% injury rate	Peak: 6% injury rate
Professional	Peak: 13% injury rate	Peak: 11% injury rate	Peak: 8% injury rate

In order to make the study more convincing, questionnaires were also issued and statistical results were calculated to compare the differences in PSI rhythm and sports injury among athletes of different sports events, gender, age group and competitive level (see **Table 9**), and PSI rhythm and sports injury risk under different training environments (high-intensity training versus low-intensity training) (see **Table 10**). The effects of different climatic conditions on PSI rhythm and sports injury (see **Table 11**).

In **Table 9**, compared with basketball players, football players have a lower injury rate during peak physical periods. Male and female athletes show different injury rates at different stages of their PSI rhythm due to physiological and hormonal differences. The injury rate of young athletes in the peak period of intelligence is lower. Due to the intensity of training and the pressure of competition, professional athletes face a higher risk of injury during peak PSI rhythms.

Table 10. PSI rhythm and risk of sports injury in different training environments.

Training environment	Physical rhythm	Emotional rhythm	Intellectual rhythm
High-intensity			
Injury rate	Peak: 15%	Peak: 12%	Peak: 9%
Recovery time	Longer	Longer	Longer
Performance impact	Peak performance	Emotional stress	Cognitive fatigue
Low-intensity			
Injury rate	Peak: 8%	Peak: 6%	Peak: 4%
Recovery time	Shorter	Shorter	Shorter
Performance impact	Steady	Balanced	Consistent

According to **Table 10**, it was found that athletes who trained intensely experienced higher injury rates at the peak of their physical, emotional, and intellectual rhythms. This is due to increased physical and psychological stress, leading to longer recovery times and a significant impact on performance, with peak performance at times of physical exertion but accompanied by emotional stress and cognitive fatigue.

In contrast, athletes who participate in low-intensity training generally have lower injury rates across all PSI rhythms. Training is less stressful, allows for shorter recovery times, and performance is more consistent without the extreme high and low fluctuations seen in high-intensity training.

In **Table 11**, a mild climate is considered to be most conducive to sports, and athletes' bodies can function at their best, with emotional stability and intellectual concentration, so the risk of sports injury is relatively low.

Table 11. Effects of different climatic conditions on PSI rhythm and sports injury.

Climate condition	Physical rhythm impact	Emotional rhythm impact	Intellectual rhythm impact	Sports injury rate
Moderate climate	Relatively stable	Emotionally stable	Good focus	Below average
Hot climate	Increased risk of dehydration	Possible emotional fluctuations	Potential for reduced concentration	Increased
Cold climate	Increased risk of muscle stiffness	Potential for low mood	Possible slower reaction times	Increased

Hot climates can lead to dehydration and heat exhaustion, affecting athletes' physical performance and recovery. Emotions may become unstable due to discomfort and fatigue, and intellectual rhythms may be impaired due to discomfort and lack of concentration caused by the heat. The rate of sports injury may increase due to excessive fatigue and improper adaptation.

Low temperatures may increase the risk of muscle stiffness and joint stiffness, leading to sports injuries. Emotionally, athletes may feel unpleasant and have difficulty staying positive in a cold environment. Intellectual rhythms may be affected because the body requires more energy to maintain body temperature, resulting in longer reaction and decision times.

In short, overtraining or overloading without adequate recovery time will lead to physical and psychological fatigue and increase the likelihood of injury. Each person's physical condition should be assessed regularly and the training plan adjusted to maintain the best physical condition. Different environmental factors should take corresponding preventive measures, the use of appropriate equipment and equipment to provide additional safety protection.

In addition, nutrition, sleep patterns and mental health are also three key factors that affect athlete performance and injury risk. Lack of essential nutrients or water impairs the body's ability to recover and performance, increasing the probability of injury. Provide proper nutritional support to speed up muscle repair, boost energy levels and ensure overall health. Sleep quality plays a crucial role in the recovery process, cognitive function and emotional stability. Not only does lack of sleep impair cognitive ability and the body's response speed, it may also lead to poor concentration, which increases the risk of injury. Anxiety, depression and stress in life can distract athletes, reduce motivation and even affect physical function, making them more vulnerable to fatigue and injury. Therefore, there should be a systematic approach, including mental health education, learning stress management skills, and professional psychological support if necessary.

5. Conclusions

Biological rhythm refers to the periodic changes of physiological and psychological functions, and rhythm is one of the basic characteristics of life activities. The human body has a biological rhythm phenomenon under any conditions and environment. Human biological rhythm is the time structure that controls human growth and development, behavioral dynamics, functional metabolism, maturity and aging, reproduction and reproduction. Due to the complexity of the human body, the laws of its time attributes are also complex and changeable. The biological rhythms of the human body include three rhythms of physical strength, emotional rhythm, and intelligence. The rhythm of physical strength reflects the physiological rhythm of the human body, the rhythm of emotion reflects the psychological rhythm of the human body, and the rhythm of intelligence reflects the mental rhythm of the human body. These three rhythms are the main factors that affect and restrict human behavior. Therefore, the ability to understand and master the three rhythm states of the human body, and use them to guide and coordinate people's schedule and activity arrangements, can improve the efficiency of human behavior.

Regardless of the complexity of the human body's biological rhythms, people have initially understood its laws, and they have been widely used in all aspects of life, which have played an important role in improving work efficiency and ensuring life safety. The relationship between the biorhythm of the human body and the competitive state is relatively complicated. People often say "play well" or "not play well". This is different from the athlete's own during training and competition. The biological rhythm is closely related. If the biological rhythm is in the climax period, it is easy to play a higher level than usual. If it is in the low tide or critical period, training and competition may not be able to perform at a higher level, and even cause sports injuries.

In the initial stage of the research, this paper introduces the concept of human biological rhythms and the methods of measuring PSI biological rhythms, and proposes questionnaire survey and expert interview methods for investigation and analysis of the relationship between athletes' sports injuries and athletes' PSI rhythms. The data classification mining algorithm of the clustering algorithm can better carry out the biological analysis between sports injury and the athlete's PSI rhythm. A biological analysis system is also constructed to make the research more intelligent, faster and more efficient.

Supplementary materials: Athlete PSI Rhythm and Sports Injury Questionnaire.

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