SIN-CHN
SCIENTIFIC PRESS PTE.LTD.

Molecular & Cellular Biomechanics 2024, 21, 184.
https://doi.org/10.62617/mcb.v21.184

Article

Protein nutrition metabolism monitoring of basketball players based on intelligent biosensor

Yu Liu[1], Jia Xu[2,*], Xiaoying Li[3]

[1] College of Physical Education, Jilin Normal University, Siping 136000, Jilin, China
[2] Department of Basic Courses, Wuhan Qingchuan University, Wuhan 430204, Hubei, China
[3] Medical Technology College, Liaoyuan Vocational and Technical College, Liaoyuan 136200, Jilin, China
*** Corresponding author:** Jia Xu, 18162665507@163.com

CITATION

Liu Y, Xu J, Li X. Protein nutrition metabolism monitoring of basketball players based on intelligent biosensor. Molecular & Cellular Biomechanics. 2024; 21: 184. https://doi.org/10.62617/mcb.v21.184

ARTICLE INFO

Received: 4 June 2024
Accepted: 21 June 2024
Available online: 10 September 2024

Abstract: With the continuous development of biological detection technology and semiconductors, human health monitoring and intervention methods will advance rapidly at the molecular level. As the lowest level hardware technology, biosensors are developing towards micro precision, adaptation, and self-calibration in terms of technological development trends. In order to achieve good sports performance, athletes must have sufficient physical fitness as the basis for creating high-level sports performance. Protein nutrition is indispensable for athletes, so it is necessary to monitor its nutrition and supplement it in time. This paper proposed a monitoring method based on digital broadcasting system to monitor protein nutrition metabolism, so as to understand the protein metabolism of basketball players in real time, which was very meaningful to improve the physical function of athletes. The experimental results in this paper showed that the muscle mass, contraction speed, training effect and immunity of group A were 30, 37, 33 and 42 points, respectively. The muscle mass, contraction speed, training effect and immunity of group B were 65, 57, 62 and 55 points, respectively. It can be found that the muscle mass, contraction speed, training effect and immunity of group A are not as good as those of group B, indicating that protein can improve the physiological needs of athletes and improve the efficiency of training.

Keywords: basketball player; physiological signa; intelligent biosensor; protein nutrition

1. Introduction

With the continuous innovation and development of modern basketball, the competition among the world's top teams is becoming increasingly fierce, and higher requirements are also placed on the physical quality of athletes. There are many ways to improve the physical quality of athletes by conventional means. For a long time, people mainly rely on scientific methods to achieve this goal. Athletes must use their physical potential to the limit if they want to beat their opponents. Finding ways to improve the physical fitness of basketball players to increase the effectiveness of their physical reserves is an important topic in current basketball research. For basketball players, physical fitness is the most basic athletic ability of the body, and it is also an important part of basketball athletic ability. Physical fitness is an important basis for basketball players to carry out technical training and improve sports performance.

The performance of a biosensor depends on the electronic conversion between the sensing electrode and the enzyme. When the distance between the enzyme active site and the electrode surface decreases, the performance will increase.

Oxidoreductases have become the best component of biosensors because their ability to achieve electron transfer complements their specificity in binding to targeted and catalytic activities.In the natural development process of human body, protein is the material basis of human life activities. It is an important part of human growth and development, reproduction and heredity, and can achieve the purpose of improving the sports level of athletes. Protein is closely related to the motor function of the human body, including muscle contraction, oxygen storage and transportation, and the regulation of various physiological functions. In addition, protein can provide a large amount of energy consumption for the human body during long-term fatigue training. Exercise can change the body's protein metabolism, but due to the different nature of exercise, the demand for protein would also have certain differences. Reasonable supply of protein has a good effect on improving muscle quality and strength. The innovation of this paper is to monitor the protein nutrition metabolism of basketball players based on the digital broadcasting system, and to know whether the athletes are lacking in protein in time, to supplement protein nutrition in time, and to improve the efficiency of training.

2. Related work

With the rapid development of basketball, the requirements for athletes' physical preparation have also increased. The process of improving a basketball player's fitness involves many different factors, including scientific training and dietary support. According to Li, medical research did not recommend that healthy people consume more dietary protein when doing resistance or endurance exercise. Studies have shown that strength training or endurance training increases protein requirements [1]. According to Btrnu, vegetarians raised more questions about the consumption of animal protein. For athletes, protein quality is a key factor in maximizing athletic performance, and his goal is to provide nutritional advice to vegetarian athletes who do not need to give up dietary preferences in order to perform well on the field [2]. Reguant-Closa A recommended a nutrition education visualization tool to help the general population put science into practice. His goal was to confirm that an athlete's fitness would support adherence to the latest sports nutrition guidelines for athletes [3]. Shaw found that people may choose a plant-based diet for a variety of reasons. This was associated with many health advantages, including the ability to avoid and manage chronic diseases. In addition to health benefits, plant-based diets can improve performance in a variety of sports [4]. The aim of the Rogatzki' study was to examine whether binding proteins and serum proteins can detect motor skills in athletes. The study found that among the subjects, the skills of the non-exercise group were lower than that of the exercise group [5]. Scholars have found that protein nutrition is very important for athletes because it is an indispensable nutrient for the human body.

With the advancement of digital broadcasting technology, more and more industries begin to use it for monitoring. Mark found that in order to adopt surveillance technology, there must be clear and widely accepted norms to guide the process. For protein nutrient metabolism measurements, these guidelines require calibration for various nutrient metabolic outputs. Using monitoring techniques and

field equipment to generate and test areas of nutrient metabolism, he performed experiments on test strips with different nominal nutrient metabolisms to develop statistical regression models [6]. According to Busquets, the ontogeny of the athlete-related macula was late. The protein content was lower, and the subsequent increase in lesion size had a direct impact on the athlete's vision. Patients are mainly observed using optical coherence tomography after treatment initiation to assess the need for further treatment [7]. Gracia-Iguacel believed that malnutrition was very common and this has a negative impact on athletes. As a single pathogenic state of malnutrition and excessive catabolic aggregation, protein energy depletion has attracted a lot of attention [8]. Scholars have found that monitoring technology has been applied in various fields, so it can also be applied to protein monitoring in order to understand the protein nutrition metabolism of athletes.

3. Protein monitoring based on digital broadcasting system and physiological signals

Biosensors have become very important in the fields of medicine, clinical analysis, and general health monitoring. The advantages of biosensors over laboratory based devices are as follows: small size, low cost, fast results, and very easy to use. In addition to the required medical and health based applications, biosensors have found key applications in several other fields such as industrial processing, agriculture, food processing, and pollution control.In order to achieve good sports performance, athletes must first have good physical fitness. There must be a foundation for creating high-level athletic performance and the natural development of human beings. Through the role of these changing factors and in accordance with the characteristics and requirements of sports, the requirements to meet the performance of high-level sports competitions are further developed [9]. It is an important part of the current development and competition of international competitive sports to find ways and methods to improve the physical fitness of athletes and to enhance the role of physical fitness of athletes [10]. The nutritional support of basketball players is through scientific, comprehensive and reasonable dietary support and nutritional supplements to ensure the needs of athletes' body metabolism and growth and development. It meets the special nutritional needs of athletes in high-intensity sports, so as to achieve the purpose of eliminating sports fatigue and restoring physical strength. The nutritional composition of basketball players is shown in **Figure 1**.

As shown in **Figure 1**: Sports nutrition is a special nutrient based on mass nutrition, and basketball is a physical activity, which must comply with the basic principles of sports nutrition. In fact, the physical quality of basketball players refers to the comprehensive quality of endurance, speed, strength, agility, special skills and other factors [11]. According to the two basic principles of universality and particularity, basketball and other sports have commonalities and individualities in terms of physique and nutritional needs.

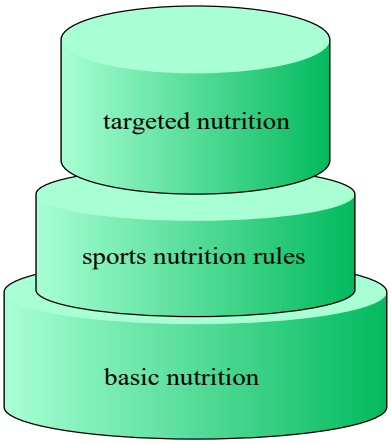


Figure 1. Nutritional composition of basketball players.

As shown in **Figure 1**: Sports nutrition is a special nutrient based on mass nutrition, and basketball is a physical activity, which must comply with the basic principles of sports nutrition. In fact, the physical quality of basketball players refers to the comprehensive quality of endurance, speed, strength, agility, special skills and other factors [11]. According to the two basic principles of universality and particularity, basketball and other sports have commonalities and individualities in terms of physique and nutritional needs.

3.1. Importance of protein to human body

(1) Protein is the most basic cell tissue.

Protein is the most important component of cells, and its content exceeds 80%. It is composed of substances in the cell membrane, and it regulates the genetic information of cells [12]. Human tissue cells are in a state of constant renewal and balance during the aging process, and protein is the substance that maintains tissue repair and regeneration. Physical exercise enhances the body's metabolism, which in turn strengthens bone, muscle, and protein content.

(2) Proteins can regulate the physiological functions of the body.

All biochemical reactions in the human body require the participation of some catalytic enzymes, and the essence of enzymes is protein. Protein has a great influence on the acid-base balance of the body. When the human body performs intense exercise, the enzyme metabolism of the human body would increase, and the blood protein would play a good buffering role to maintain the balance in the body. Hormones that regulate the body's physiological functions include insulin, pituitary hormones, and the like.

(3) Protein is involved in energy supply during exercise.

The free amino acids in the body can also be used as an energy source, but the proportion of energy is very low, accounting for about 5% to 18% of the total energy consumption. Amino acids produced by the renewal of tissue proteins also provide a certain amount of energy. However, in the process of exercising, the role of protein is relatively small, and the body would decompose it only when the body's intake of sugar and body fat is not enough.

3.2. Monitoring method of digital broadcasting system based on zigbee wireless communication technology

With the development of society and economy, optical fiber technology has been applied more and more in all walks of life. As a product of the development of new technologies, digital broadcasting system would definitely become an important part of the application of optical fiber communication technology [13]. As an emerging technology, optical fiber communication technology has different application scopes.

The networked architecture of digital broadcasting system has the function of interconnection, which can not only accurately meet the current needs of users, but also adapt to future needs [14]. The processing characteristics of the all-digital audio signal can not only ensure the purity of the signal, but also greatly improve the transmission distance, as shown in **Figure 2**:

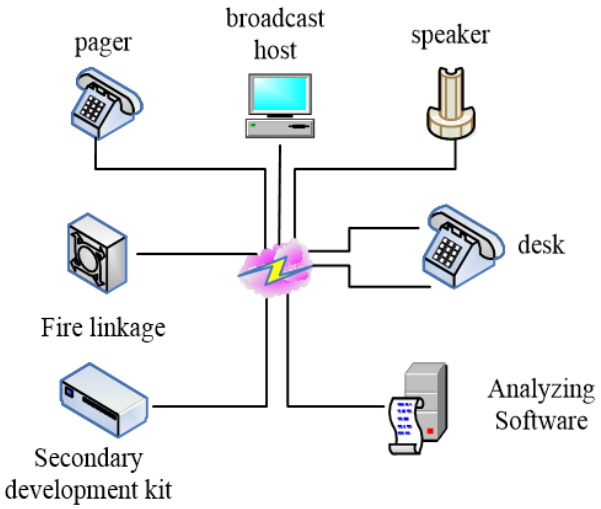


Figure 2. Digital broadcasting system.

As shown in **Figure 2**: The digital broadcasting system can realize multiple data collection at the same sampling point, and set up multiple data collection points on multiple data points to improve the processing capability of each data point. The monitoring points and the locations of each collection point can be reasonably arranged, and finally, the system can predict the protein nutrition metabolism in a specific time in the future [15]. This paper mainly studies the wireless communication technology of ZigBee and GPRS and establishes the corresponding network structure. This paper conducts an in-depth study on the probability neural network algorithm.

ZigBee is a standard-based two-way wireless communication technology, which integrates the requirements of construction cost, transmission distance and network networking mode [16]. The system has the advantages of low energy consumption, low occupation space, low construction cost, reliable data exchange, large node capacity, flexible networking mode, and good compatibility. Its data transfer rates are so fast that it can operate on battery power for months or years. The mesh topology of ZigBee is shown in **Figure 3**:

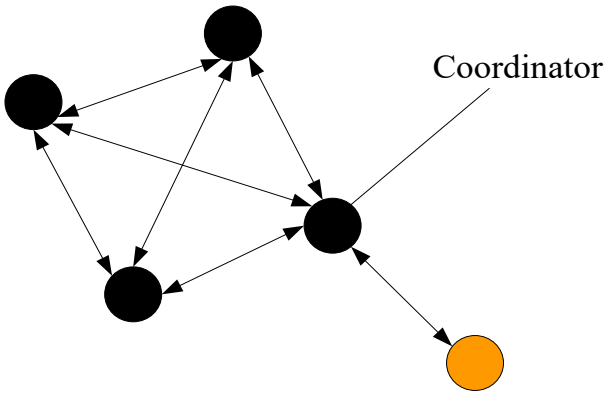


Figure 3. ZigBee mesh topology.

As shown in **Figure 3**: The topology selection of wireless sensor network is the key to constructing wireless sensor network. When it is assumed that the distance between the device and the access point does not exceed 100 meters, the topology is ideal. When it is assumed that a longer transmission distance is required, a tree structure can be used to extend the transmission distance. Under the premise of high network reliability, mesh topology can cope with the failure of routers by providing redundant paths to ensure the reliability of the system [17].

GPRS network is composed of many nodes, it is a kind of mobile phone routing that manages and transforms. The composition of the GPRS network is shown in **Figure 4**:

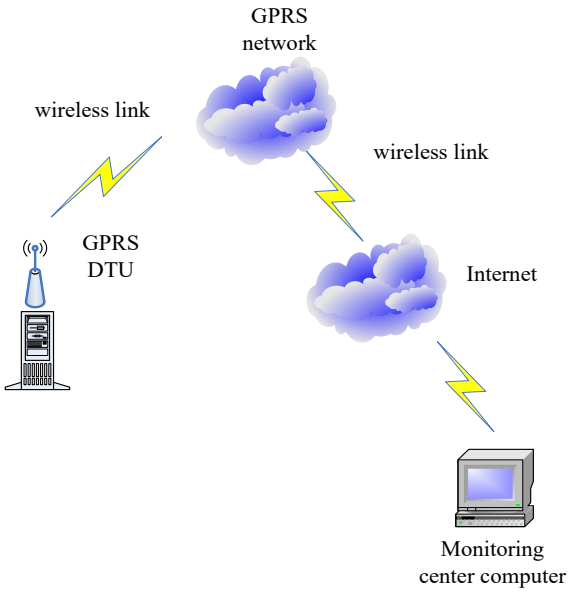


Figure 4. Structural composition of GPRS network.

As shown in **Figure 4**: GPRS communication procedure: when the user wants to join a specific network, he first sends this request to it, so that the user can know the address of this channel [18]. However, if several users send a request at the same time, then the system would detect and determine whether there is a conflict between them at this time, and then assign their channels in turn. The user sends a confirmation request to the system according to his channel address, and then

confirms it. If the user does not receive a message confirmation from the system, the data would be sent to the system [19].

Probabilistic Neural Networks (PNNs) can learn faster and classify data more accurately and perform better under fault conditions. In order to obtain an approximation of the probability density function determined from the data provided, this paper assumes a quantity $g = 1,2,\ldots,G$, for all identified classes, a probability density function such as $b_1(a), b_2(a),\ldots, b_G(a)$. The probability density function for multiple variables is expressed as Equation (1):

$$b(a) = \frac{1}{l\sigma_1 \ldots \sigma_n} \sum_{i=1}^{l} F\left(\frac{a_i - a_1}{\sigma_1} \ldots \frac{a_i - a_n}{\sigma_n}\right) \tag{1}$$

F is a weight function that needs to be carefully chosen, and $\sigma_1 \ldots \sigma_n$ represent the standard deviation $a_1, \ldots, a_n$ measured between them relative to the mean of the n variables. Since the Gaussian function is used as the probability density function, the definition of the Gaussian function is changed to the following form as in Equation (2):

$$b_g(a) = \frac{\sum_{i=1}^{l_g} exp\left(-\sum_{j=1}^{n} \frac{\left(a_{ij} - a_j\right)^2}{2\sigma_j^2}\right)}{\sigma_j} \tag{2}$$

where σ_j represents the smoothing parameter associated with the *j*th coordinate, and the a_{ij}neuron constitutes the input of the ith summation neuron, so the output layer determines the vector according to the Bayesian decision and the outputs of all neurons as in Equation (3):

$$G^*(a) = argmax_g\{b_g(a)\} \tag{3}$$

Among them, $G^*(a)$ represents the calculation of the matching degree between the pattern input samples and the model, and the accumulation layer combines the pattern layer units of each class. The number of neurons is the number of sampled classes, so this method has high complexity in massive data sets.

The k-means clustering algorithm optimizes the neurons in the model layer to obtain the optimal number of morphological cores, thereby simplifying the structure of the PNN and obtaining the K-PNN algorithm [20]. The gth summation neuron generates the following output signal to the decision layer:

$$b_g(a) = \frac{\frac{\left(a_{ij} - a_j\right)^2}{2\sigma_j^2}}{\sigma_j^g} \tag{4}$$

where σ_j^g is the smoothing parameter for the gth coordinate, so that the records of each cluster can be similar to each other, but the method of packet processing depends on the sum of the squared distances between the input data and the center of the cluster. An initial cluster is first defined, and then it is continuously updated until it gets the position it has changed, such as Equation (5):

$$S\left(l_g, k\right) = \frac{1}{k!} \sum_{i=1}^{k} (-1)^{k-i} \binom{k}{i}^{l_g} \tag{5}$$

The function rounds to the nearest integer as in Equation (6):

$$i_{s,g} = round\left(\frac{S}{N} l_g\right) \tag{6}$$

The quotient of the number of neurons in the training dataset is shown in Equation (7):

$$R(s) = \frac{1}{l}\sum_{g=1}^{G} i_{s,g} \tag{7}$$

The specific implementation process of the method: people can input a sample $i_{s,g}$ in the input layer, and then use the k-means clustering algorithm to obtain the optimal number of neurons in the model layer *N*. The input data is divided into *i* categories, first use the sampling to train the network l_g, and then carry out the data input. Finally, the distance between each input data and sampling is calculated, and the average of each category is calculated, which is equal to the number of neurons in each category. By comparing the average values for each category, it is possible to determine which category the data belongs to and divide it into categories with similar values.

3.3. Metabolic monitoring based on physiological signal detection

Blood oxygen saturation(SpO_2), electrocardiogram (ECG) and blood pressure are the key physiological signs obtained. Other signs, such as blood oxygen levels, can reveal the basic body functions that sustain life, and monitoring the physical condition of the athlete can timely and accurately understand the physical condition of the athlete. This has a great guiding role for long-term monitoring of athletes' protein nutrition metabolism status.

In this paper, based on the color model, a pattern recognition classifier is constructed by using Mahalanobis distance, and an unsupervised image segmentation model is established, as shown in Equation (8):

$$D(z,a) = \left[(z-a)^T C^{-1}(z-a)^{\frac{1}{2}}\right] \tag{8}$$

The covariance distance of the data is represented by the Mahalanobis distance $D(z,a)$, which is a useful tool for determining how similar two sets of unidentified samples are. The vector z is an average estimate of the protein region and can represent any point in space. $(z-a)^{\frac{1}{2}}$ is the covariance matrix of the sample points in the protein region.

Blood oxygen saturation (SpO_2) is an important indicator, it represents the volume of total hemoglobin (HbO_2), and it represents the percentage of total hemoglobin (Hb). The oxygen content in blood is the basic element of human life activities, which would produce oxyhemoglobin and transport it to various parts of the body. The blood oxygen saturation can be expressed by Equation (9):

$$SpO_2 = HbO_2/(HbO_2 + Hb + COHb + MetHb) \times 100\% \tag{9}$$

HbO_2 represents the concentration of oxyhemoglobin and Hb represents the concentration of deoxyhemoglobin. Blood oxygen saturation can be defined by Equation (10):

$$SpO_2 = HbO_2/(HbO_2 + Hb) \times 100\% \tag{10}$$

If 100 mL of blood contains 20 mL of oxygen, then the oxygen saturation is 100%. If respiratory failure occurs, the oxygen saturation of the blood is below 90%, and in severe cases it would drop to 80%.

The conventional method is to use electrochemical methods for detection, first collect blood samples, and then use a blood gas analyzer for analysis to obtain blood oxygen partial pressure and carbon dioxide partial pressure values, and then calculate blood oxygen saturation. This method is not only complicated to operate, but also damages the human body. The intermittent detection method cannot realize real-time monitoring. The most widely used method is photoplethysmography, which uses photoelectric sensors to detect changes in blood volume.

The thickness and concentration of the solution layer are related to the amount of transmitted light absorbed, and the Lambert-Beer law states that the thickness and concentration of the medium affect the amount of transmitted light absorbed:

$$I = I_o e^{-\varepsilon cd} \tag{11}$$

In the equation, I represents the transmitted light intensity, which is a constant, which in the human body would change with the beating of blood vessels, while other tissues, such as skin, bones, muscles, veins, etc., would remain unchanged.

Taking into account the difference of individuals, the relationship between the light intensity ratio and oxygen saturation at two different wavelengths is usually derived from the relationship between the quadratic function:

$$SpO_2 = a_1 + a_2 K + a_3 K^2 \tag{12}$$

where a_1,a_2,a_3 are constants.

ECG signal refers to the change of electric potential caused by the transmission of electrical ions in cardiomyocytes and in vitro when the heart is working. The heart pumps blood from the heart through mechanical contractions, and each contraction causes electrical stimulation, and electrical stimulation of the atria and ventricles can be transmitted to the body surface through body tissues. An electrocardiogram is a recording curve generated by collecting the potential changes on the surface of the human body, as shown in **Figure 5**:

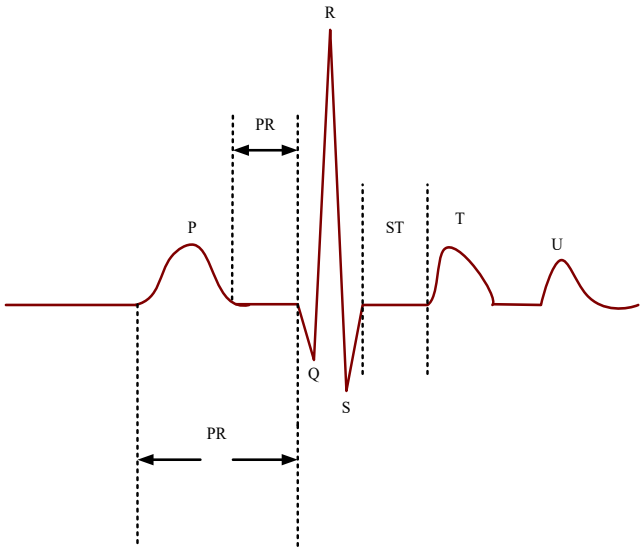


Figure 5. ECG signal change diagram.

As shown in **Figure 5**: In clinical, the examination based on ECG signal is the most effective method in the diagnosis room. During an arrhythmia, the electrocardiogram shows wide waves with large peaks, sometimes jumping in the opposite direction:

$$Ther = k \times b_n \tag{13}$$

The point b with the largest amplitude can be found in the waveform data, and then the coefficient k is added to the amplitude of this point to obtain the threshold.

4. Experiments of protein nutrition metabolism monitoring

4.1. Monitoring effects of different methods

Firstly, the network performance of ZigBee is tested and then analyzed. On this basis, several different modes are compared and verified in this paper.

The experiment considers the influence of external factors, and analyzes the proportion of the number of packets lost when a node transmits 1000 18-byte data packets continuously. The indoor and outdoor data packet loss rates were simulated using MATLAB, as shown in **Figure 6**:

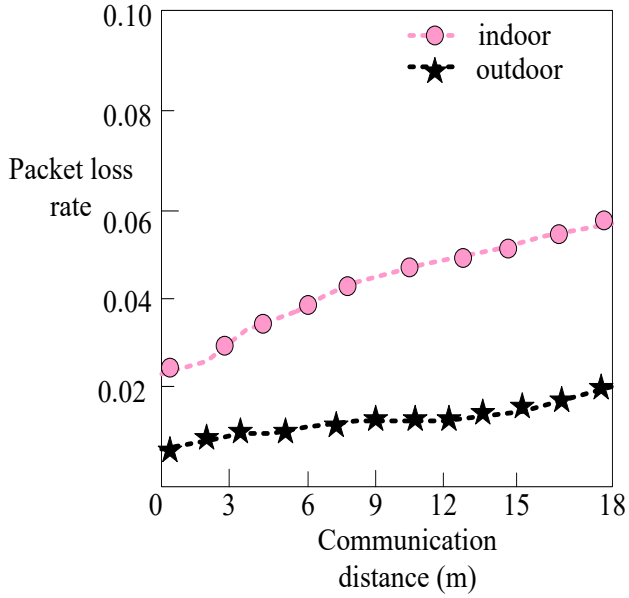


Figure 6. Comparison of packet loss rates indoors and outdoors.

As shown in **Figure 6**: The packet loss rate is the average number obtained by the receiving end sending data packets over the same distance through multiple transmissions. Due to the larger outdoor space and less interference factors, the outdoor packet loss rate is better than that of indoors under the same communication distance.

In order to test the prediction effect of K-PNN algorithm, 600 samples out of 660 samples were selected for network training, and the other 60 samples were used as experimental tests. On this basis, the relationship between PNN and K-PNN is compared, and the simulation results of MATLAB are given as shown in **Figure 7**:

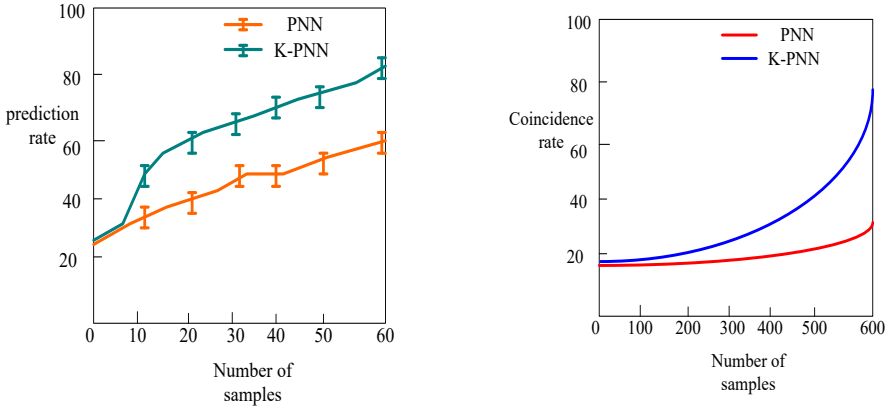


Figure 7. Prediction results and coincidence rates of the two algorithms. **(a)** prediction results of PNN and K-PNN algorithms; **(b)** coincidence rate of the two algorithms.

As shown in **Figure 7**: **(a)** shows that the PNN method has a relatively low relative accuracy in numerical prediction, while the prediction accuracy of the K-PNN method is significantly greater than that of the PNN method; **(b)** shows that in the training samples below 200, the coincidence rate of the prediction results of the two methods is basically the same, but when there are more than 200 training samples, their prediction results would be very different. With the increase of the number of training samples, the prediction effect of the K-PNN method on the samples is also improved accordingly. Therefore, the K-PNN method can well solve the shortcomings of the PNN method in big data, and has a higher prediction accuracy.

4.2. Effect of exercise on protein metabolism

Athletes who perform strength training for a long time can significantly improve the anabolism of protein in the body and increase the strength of muscles. Strength training increases muscle volume, muscle fibers, and muscle strength. Rapidly contracting muscle fibers undergo adaptive changes, their muscle protein content increases, and the total amount of contractile protein also increases. This paper divides 100 students from a college boy basketball major into 50 students in each group. Group A was given ordinary diet, and group B was given protein nutrient solution. The basic information of the subjects is shown in **Table 1**:

Table 1. Basic information of subjects.

Index	Index	Number of people	Percentage
age	15–18	42	42%
	19–22	30	30%
	23–26	28	28%
training years	1–3 years	70	70%
	over 3 years	30	30%

As shown in **Table 1**: the subjects are very young, all under the age of 30, 30% of the subjects have been trained for more than three years, and 70% of the subjects have been trained for more than three years. Strength training can promote insulin secretion, which can increase the sensitivity of muscle cells to insulin, while eccentric training can reduce the sensitivity of muscle cells to insulin, and this decline would continue after training. This change is due to the decrease in the rate of glucose transport due to centrifugation, thereby reducing the rate of glycogen synthesis. Insulin resistance and temporary inhibition of glycogen regeneration may cause hyperinsulinemia, which may reduce the rate of muscle protein synthesis.

4.2.1. Strength training plan

Perform strength training three times a week for 60 min each time, including warm-up: 10 min (running or dynamic stretching). Main training: squats, hard pulls, push bench, barbell rowing, dumbbells, biceps curls, and triceps downward pressure. Each action is performed in 3–4 groups, with 8–12 repetitions per group. Cooling: 10 min (static stretching).

4.2.2. Dietary plan

Group A (regular diet group): The daily total energy intake is determined based on the individual's basal metabolic rate (BMR) and activity level. The specific arrangement is shown in **Table 2**:

Table 2. Group A dietary plan.

Classification	Meals	Specifications
Breakfast (7:00)	Oats	1 bowl
	Boiled eggs in water	3
	Milk	1 cup
	Fruit	1 apple
Lunch (12:00)	Whole wheat rice	1 bowl
	Roast chicken breast	200grams
	Broccoli	1 copy
	Carrot	1 copy
Dinner (18:00)	Italian pasta	1 bowl
	Lean beef	200 grams
	Green salad	1 copy

Group B (protein nutrient solution group): The daily total energy intake is also determined based on individual BMR and activity levels. The specific arrangement is shown in **Table 3**:

Table 3. Group B dietary plan.

Classification	Meals	Specifications
Breakfast (7:00)	Oats	1 bowl
	Boiled eggs in water	3
	Milk	1 cup

Table 3. (*Continued*).

Classification	Meals	Specifications
Breakfast (7:00)	Fruit	1 apple
Add meals in the morning (10:00)	Protein nutrient solution	1 cup
Lunch (12:00)	Whole wheat rice	1 bowl
	Roast chicken breast	200 grams
	Broccoli	100 grams
	Carrot	100 grams
Dinner (18:00)	Italian pasta	1 bowl
	Lean beef	200 grams
	Green salad	1 copy
Add dinner at night (21:00)	Protein nutrient solution	1 cup
	Cheese	50 grams
	Nuts	30 grams

Specific plan description.

BMR calculation uses the Harris Benedict formula to calculate the BMR of each participant, where male BMR = 88.362 + (13.397 *x* body weight kg) + (4.799 *x* height cm) − (5.677 *x* age years). Adjust the total energy intake according to the level of activity, design a dietary structure to ensure a balanced diet for both groups, including all essential nutrients, as shown in **Table 4**:

Table 4. Essential nutrients.

Sequence	Nutrient	Function
1	Carbohydrate	Provide the energy needed for training and daily activities
2	Protein	Support muscle repair and growth
3	Fat	Provide long-term energy and essential fatty acids
4	Vitamins and Minerals	Supporting overall health and immune function
5	Protein nutrient solution formula (whey protein, branched chain amino acids, and glutamine)	Enhance protein synthesis and reduce muscle breakdown

4.2.3. Data collection and recording

In data collection and recording, intelligent wristbands are used to continuously monitor the daily activity level, heart rate, sleep quality, etc. of college basketball players, and continuous behavioral data is collected to evaluate the impact of different dietary plans combined with strength training on the physical indicators of athletes.

(1) Data collection indicators.

1) Daily activity level: Collect daily total steps.

2) Heart rate monitoring: collecting average heart rate during training.

3) Sleep quality: Collect daily total sleep time.

(2) Data recording.

Equipment wearing requirements: Athletes should wear smart wristbands 24 hours a day (except during bathing and charging) to ensure that the devices are correctly worn, tightly attached to their wrists, and to ensure data accuracy and synchronization. Every morning and evening, synchronize the smart bracelet with the mobile app and upload the data to the research database regularly (once a week). Record and export the data using the smart bracelet app. The data export format is Excel, which facilitates subsequent data analysis.

Endurance exercise increases mitochondrial number, volume, mitochondrial protein, and constitutive enzyme activity in muscle. In endurance training, due to the action of arginine, insulin secretion would be reduced, and aerobic exercise can reduce insulin secretion, improve insulin sensitivity and improve blood sugar tolerance. The effect of this exercise at rest affects the body's metabolism, so that the frequency of fluctuations in insulin production decreases with each peak. Insulin and amino acids are key to controlling muscle protein synthesis in local muscle. Insulin secretion decreases under starvation conditions, resulting in a decrease in the rate of skeletal muscle protein synthesis. This paper also analyzes the daily nutritional intake of athletes, as shown in **Table 5**:

Table 5. Daily nutritional intake of athletes.

Nutrients	Intake	Recommended supply
Heat（Kcal）	3380	4215
Sugar（g）	304.1	630
protein（g）	145	139
Fat%（Calories）	175	119

As shown in **Table 5**: Only by taking in enough nutrients can people maintain the balance of the body. Therefore, it can be seen from the survey results that the dietary structure of young basketball players should be dominated by high protein. Nutrition is the key to the normal development of the human body and the protection of good health. If the basic nutrition cannot be guaranteed, it would not only have a serious impact on the body, but also cause serious harm to the body, and even lead to serious health problems.

In addition, attention should be paid to the nutritional structure of athletes' diet, eating habits, and the growth of nutrients required for growth and development. The following is a survey of athletes on the nutritional importance of protein as shown in **Tables 6** and **7**:

Table 6. Athletes in Group A consider the importance of protein nutrition.

Importance	Number of people	Percentage
Very important	25	50%
more important	15	30%
generally important	5	10%
unimportant	3	6%
very unimportant	2	4%

Table 7. The importance of protein nutrition considered by athletes in Group B.

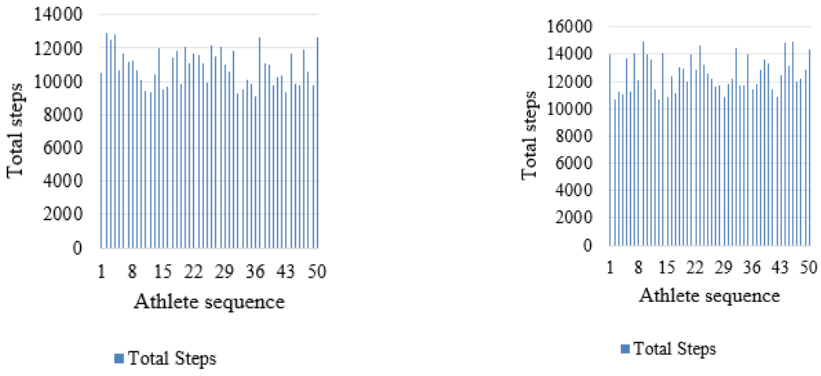
Importance	Number of people	Percentage
Very important	24	48%
more important	16	32%
generally important	4	8%
unimportant	3	6%
very unimportant	3	6%

As shown in **Tables 6** and **7**: Basketball training is a long-term and complex process of personality cultivation and physical exercise. It is from the early talent screening and scientific training to give full play to the physiological function and plasticity of the human body, so as to achieve the highest state of basketball. Therefore, the influence of nutrition on physical fitness should be strengthened, and the physical fitness related to sports should also be improved to improve their physical development potential, which is an important topic for basketball players at present.

4.2.4. Data comparison

(1) Daily activity level.

By comparing the daily total steps, this article analyzes the impact of protein nutrition on the daily activity level of athletes. The daily total steps of two groups of athletes on a certain training day were used as indicators to compare their data. The final results are shown in **Figure 8**:



(A) **(B)**

Figure 8. Comparison results of daily activity levels. **(A)** shows the daily activity levels of athletes in Group A; **(B)** shows the daily activity levels of athletes in Group B

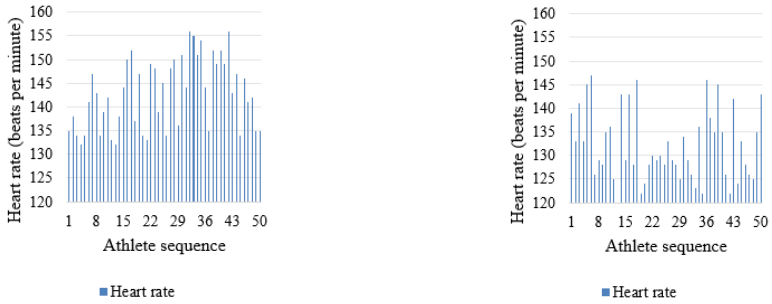
From **Figure 8**, it can be seen that in the comparison of daily activity levels, the average activity level of athletes in Group B is generally higher than that of athletes in Group A. On training days, from **Figure 8A**, it can be seen that the average total daily steps of Group A athletes based on a regular diet arrangement were 10849.02; From **Figure 8B**, it can be seen that the average daily total number of steps for athletes in Group B based on a protein nutrient diet arrangement is 12617.82. From this result, it can be seen that the dietary arrangement of protein nutrient solution helps to improve the daily step performance of athletes. Under protein

supplementation, the physical condition and athletic ability of athletes are improved to a certain extent, leading to more activity.

(2) Comparison of heart rate monitoring.

The comparison of heart rate monitoring is used to evaluate the recovery status of the body. This article also uses the heart rate monitoring results of two groups of athletes on a certain training day as an indicator to compare their data. The final results are shown in **Figure 9**.

From **Figure 9**, it can be seen that under the comparison of heart rate monitoring, the average heart rate of Group A athletes based on regular dietary arrangements reached about 142.8 beats per minute; The average heart rate of Group B based on protein nutrient solution diet arrangement reached approximately 132.1 beats per minute. From **Figure 9A** and **Figure 9B**, it can be seen that the average heart rate of athletes in Group B is significantly lower than that of Group A, indicating better heart rate control during training. The additional supplementation of protein nutrient solution helps them recover faster and cope more effectively with training loads.

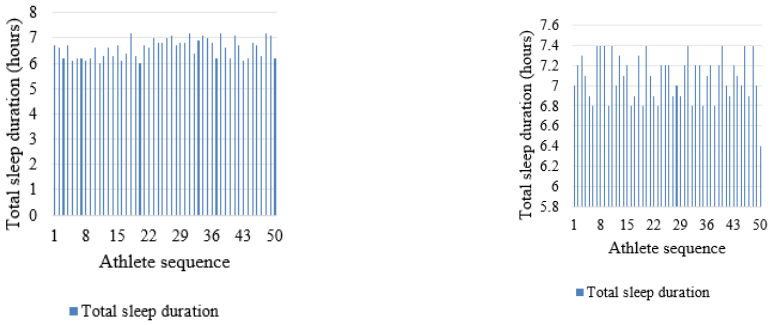


(A) **(B)**

Figure 9. Comparison results of heart rate monitoring. **(A)** shows the heart rate monitoring results of athletes in Group A; **(B)** shows the heart rate monitoring results of athletes in Group B.

(3) Comparison of sleep quality.

In the comparison of sleep quality, the impact of protein nutrition on athlete recovery and overall health was measured by comparing the total sleep time of two groups of athletes on training days. The comparison results are shown in **Figure 10**.



(A) **(B)**

Figure 10. Comparison results of sleep quality. **(A)** shows the sleep quality of athletes in Group A; **(B)** shows the sleep quality of athletes in Group B.

From **Figure 10A** and **Figure 10B**, it can be seen that the average total sleep time of athletes in Group B is about 7.1 hours, significantly higher than Group A's 6.6 hours. This indicates that athletes in Group B can achieve longer sleep times with the supplementation of protein nutrient solution. These data indicate that athletes in Group B can achieve longer sleep time with the support of protein nutrient solution, thereby better recovering and improving sports performance.

Figure 11 shows the physical conditions of group A and group B after training with the same intensity and time:

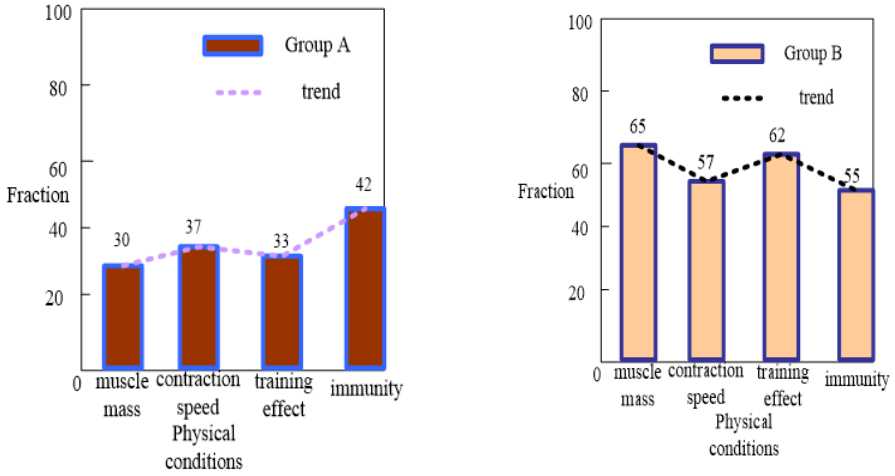


Figure 11. Comparison of the physical conditions of the two groups after training. **(A)** Physical condition of group A; **(B)** Physical condition of group B.

As shown in **Figure 11**: From **(A)**, it can be found that the muscle mass of group A is 30 points, the muscle contraction speed is 37 points, the training effect is 33 points, the immunity is 42 points, and the score is low; from **(B)**, it can be found that the muscle mass of group B is 65 points, the muscle contraction speed is 57 points, the training effect is 62 points, the immunity is 55 points, and the score is higher. It can be seen that before and after exercise, athletes would improve the quality of the body by adding protein, thereby accelerating muscle contraction. If people consume too much protein, it would not only affect the training effect of athletes, but also cause the body's immunity to decrease, and even lead to exercise-induced anemia.

Therefore, a reasonable diet and nutrition is to provide the human body with a balanced diet that is suitable for health. Reasonable nutrition is the key for athletes to obtain excellent sports performance. A reasonable diet and nutrition can promote the physical development of athletes, eliminate exercise-induced fatigue, and improve the sports level of athletes. This lays a solid material foundation for the achievement of elite athletes.

4.2.5. Educational intervention

Through systematic educational intervention, improving the awareness and practice of comprehensive nutrition among basketball players and their related personnel not only helps optimize their performance and recovery, but also enhances their health awareness and quality of life. Firstly, regularly invite nutrition experts

and exercise nutritionists to hold lectures and seminars, introducing the latest research and applications of basic nutrition knowledge, exercise nutrition, and personalized nutrition. And provide videos, articles, and online courses through online learning platforms, making it convenient for athletes to learn anytime, anywhere. In addition, arrange one-on-one consultations with nutritionists to develop personalized nutrition plans for athletes and regularly track and evaluate their dietary status. Teach athletes how to prepare nutritious meals in real life through nutrition workshops and simulation training activities. Finally, regular questionnaire surveys, dietary record analysis, and physical fitness tests are conducted to evaluate the effectiveness of educational interventions, and based on feedback, education plans are continuously improved to ensure that athletes receive optimal nutritional support during training and competition.

5. Conclusion

Biosensors have many advantages, such as high speed, high accuracy, ease of use, and generally affordable. They can make the detection and monitoring process more convenient. The main goals of biosensors are prevention and monitoring.Protein nutrition is an important material basis for basketball players to maintain physical health and basic nutrition. The solution of nutritional problems would become the ultimate subject of sports research, and providing balanced protein nutrition is an important means for athletes to obtain comprehensive nutrition. In order to understand the nutritional and metabolic status of Chinese basketball players, ZigBee wireless communication technology was used for real-time monitoring and a monitoring method based on physiological signals. By monitoring the protein nutrition metabolism of athletes, timely nutritional supplements are provided to athletes to improve their physical functions, so that athletes have a greater advantage in training and competition. In order to ensure the effectiveness of the proposed method, an experimental method was used for monitoring. The results show that this method has a good monitoring effect and can be used for protein nutrition metabolism monitoring. During exercise time, implementing a standard diet and regular training for athletes, consuming high protein drinks under the guidance of a nutritionist, and combining personalized training strategies can significantly improve athlete recovery and performance. Coaches and athletes should apply this strategy, regularly monitor nutrition and training effectiveness, and adjust plans to achieve optimal results. Through the investigation of subjects, it is found that sufficient protein can not only enhance muscle strength, but also enhance the immune function of athletes, so this paper has certain theoretical significance. However, in the course of the experiment, due to the limited time and energy, no comprehensive experiment was carried out, so it should be paid attention to in future research.

Author contributions: Conceptualization, YL and JX; methodology, XL; software, XL; validation, JX, and XL; formal analysis, XL; investigation, XL; resources, YL; data curation, JX; writing—original draft preparation, YL; writing—review and editing, YL; visualization, JX; supervision, JX; project administration, XL; funding

acquisition, YL. All authors have read and agreed to the published version of the manuscript.

Ethical approval: Not applicable.

Conflict of interest: The authors declare no conflict of interest.

References

1. Li D. Factors affecting the difference of protein supplements on physical fitness. Network Modeling Analysis in Health Informatics and Bioinformatics. 2021; 11(1). doi: 10.1007/s13721-021-00335-1
2. Bătrînu MG, Tero-Vescan A, Miklos A. Biochemical Controversies Regarding the Use of Vegetal Proteins in Performance Athletes. Acta Biologica Marisiensis. 2020; 3(2): 1-9. doi: 10.2478/abmj-2020-0006
3. Reguant-Closa A, Harris MM, Lohman TG, et al. Validation of the Athlete's Plate Nutrition Educational Tool: Phase I. International Journal of Sport Nutrition and Exercise Metabolism. 2019; 29(6): 628-635. doi: 10.1123/ijsnem.2018-0346
4. Shaw KA, Zello GA, Rodgers CD, et al. Benefits of a plant-based diet and considerations for the athlete. European Journal of Applied Physiology. 2022; 122(5): 1163-1178. doi: 10.1007/s00421-022-04902-w
5. Rogatzki MJ, Morgan JE, Baker JS, et al. Protein S100B and Brain Lipid-Binding Protein Concentrations in the Serum of Recently Concussed Rugby Players. Journal of Neurotrauma. 2021; 38(16): 2247-2254. doi: 10.1089/neu.2021.0004Thompson
6. MJ, White DJ. Field Calibration and Spatial Analysis of Compaction-Monitoring Technology Measurements. Transportation Research Record: Journal of the Transportation Research Board. 2007; 2004(1): 69-79. doi: 10.3141/2004-08
7. Busquets MA, Sabbagh O. Current status of home monitoring technology for age-related macular degeneration. Current Opinion in Ophthalmology. 2021; 32(3): 240-246. doi: 10.1097/icu.0000000000000756
8. Gracia-Iguacel C, González-Parra E, Mahillo I, et al. Criteria for classification of protein–energy wasting in dialysis patients: impact on prevalence. British Journal of Nutrition. 2019; 121(11): 1271-1278. doi: 10.1017/s0007114519000400
9. Chen H, Ye S, Zhang D, et al. Change Detection based on Difference Image and Energy Moments in Remote Sensing Image Monitoring. Pattern Recognition and Image Analysis. 2018; 28(2): 273-281. doi: 10.1134/s1054661818020062
10. Liu XX, Luo XF, Luo KX, et al. Small RNA sequencing reveals dynamic microRNA expression of important nutrient metabolism during development of Camellia oleifera fruit. International Journal of Biological Sciences. 2019; 15(2): 416-429. doi: 10.7150/ijbs.26884
11. Bernard JK, Dildeep V. DL-Methionine and Vitamin C Effects on Growth and Nutrient Metabolism of Guinea Pigs Supplemented with Dietary Lead. International Journal of Current Microbiology and Applied Sciences. 2019; 8(06): 2496-2505. doi: 10.20546/ijcmas.2019.806.299
12. Krehbiel CR. Bovine Respiratory Disease Influences on Nutrition and Nutrient Metabolism. Veterinary Clinics of North America: Food Animal Practice. 2020; 36(2): 361-373. doi: 10.1016/j.cvfa.2020.03.010
13. Hasan MS, Humphrey RM, Yang Z, et al. Effects of dietary inclusion of GuarPro F-71 on the growth performance and nutrient metabolism in young growing pigs. Journal of Applied Animal Nutrition. 2020; 8(3): 143-150. doi: 10.3920/jaan2020.0015
14. Yang P, Qian J, Xiao W, et al. Bioactive Compound Prodigiosin in Vivo Affecting the Nutrient Metabolism of Weaned Rats. ACS Omega. 2018; 3(12): 17474-17480. doi: 10.1021/acsomega.8b02476
15. Zhou J, Wang L, Yang L, et al. Different dietary starch patterns in low-protein diets: effect on nitrogen efficiency, nutrient metabolism, and intestinal flora in growing pigs. Journal of Animal Science and Biotechnology. 2022; 13(1). doi: 10.1186/s40104-022-00704-4
16. Putman AK, Brown JL, Gandy JC, et al. Changes in biomarkers of nutrient metabolism, inflammation, and oxidative stress in dairy cows during the transition into the early dry period. Journal of Dairy Science. 2018; 101(10): 9350-9359. doi: 10.3168/jds.2018-14591
17. Karatayev AY, Mehler K, Burlakova LE, et al. Benthic video image analysis facilitates monitoring of Dreissena populations across spatial scales. Journal of Great Lakes Research. 2018; 44(4): 629-638. doi: 10.1016/j.jglr.2018.05.003
18. Gorine G, Pezzullo G, Mandic I, et al. Ultrahigh Fluence Radiation Monitoring Technology for the Future Circular Collider at CERN. IEEE Transactions on Nuclear Science. 2018; 65(8): 1583-1590. doi: 10.1109/tns.2018.2797540

19. Kim Y, Kim SH. Implications of COVID-19 Cell Broadcasting System (CBS) Message Analysis using Data Visualization. Journal of Digital Contents Society. 2021; 22(11): 1867-1875. doi: 10.9728/dcs.2021.22.11.1867
20. Becker L, Dupke A, Rohleder N. Athlete burnout is related with C-reactive protein levels in dried blood spots in young and old men. Brain, Behavior, and Immunity. 2019; 81: 30-31. doi: 10.1016/j.bbi.2019.08.105