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# *Prediction Model of the Influence of Physical Training on the Percentage of Body Fat of College Students Based on Artificial Neural Network*

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***Keywords:*** Percentage of Body Fat, Physical Training, Artificial Neural Network, SVM Algorithm

***Abstract:*** In the past ten years, the health level of college students has declined significantly. Regular exercise is a good living habit, which can reduce the risk of heart disease, obesity and related mental health. The purpose of this study is to use artificial neural network to study the change trend of college students' body fat percentage in physical training. The results showed that, during the period of 1-8 months, the percentage of body fat of male and female students selected in the experiment gradually declined after physical training. At the early stage of training, the percentage of body fat of males was close to 0.21 and declined slowly, while as the physical training continued, the decline rate gradually increased, and finally became slow and gradually close to 0.11 indefinitely. The percentage of body fat of female students also showed the same trend, with an initial BMI of about 0.35, gradually approaching 0.21. Then the percentage of body fat of college students who had undergone 36-43 months of physical training was studied and analyzed. This paper found that the percentage of body fat of college students turned again when it was gradually close to the normal value, and there was a growing trend. Males gradually showed an upward trend when it dropped to 0.11, and the growth rate was small, while females gradually increased from about 0.2. Based on the experimental results of analyzing the percentage of body fat of college students using artificial neural network technology, firstly, physical training is very effective for reducing the percentage of body fat of college students, but meanwhile, students should pay attention to the intensity and duration of exercise. Secondly, it is more important to monitor the health condition regularly.

## 1. Introduction

Recently, the global prevalence of non-communicable diseases has increased, and they may

become the main cause of death. The global level of obesity has tripled since 1975. In order to cope with the threat of a sedentary lifestyle, physical activity is one of the key factors, and physical activity can properly regulate the body. The benefits of sports are obvious, the optimal level of which can stimulate development, meet sport's needs, and enhance heart function, thus improving flexibility of muscles and joints and strengthening muscles and bones.

With the improvement of people's living standards, people are paying more and more attention to their health and diet, and the concept of body fat percentage arises at the historic moment. In recent years, more and more scholars began to study the percentage of body fat. Harmouche Karaki Mireille found that the prevalence of obesity is also related to the reduction of physical activity (PA). There was credible evidence that there is a negative correlation between total PA and body fat percentage. Despite public health efforts to improve the level of PA, many studies have shown that there is a considerable degree of physical inactivity among college students. Therefore, PA intervention for college students is essential to improve the health-related quality of life of college students [1]. Lowe Michael R used dual energy X-ray absorptiometry (DEXA) to evaluate the rate of fat gain, and studied the predictive effectiveness of six variables that predicted weight gain in previous studies: depression, disinhibition, family history of overweight, dissatisfaction with body, self-reported diet and weight inhibition (the difference between the highest weight in the past and the current weight). His research showed that most of the non-clinical freshmen are in the healthy weight range, and weight inhibition is a predictor of long-term fat gain [2]. Kim Ji-Woon discussed the influence of 12-week cycle training on the health related constitution of obese female college students and the risk factors of metabolic syndrome. His research results showed that compared with the control group, the weight, percentage of body fat and body mass index of the circulatory training group decreased significantly. All fitness indicators related to health showed relative effects between groups or over time. Finally, it was concluded that the 12-week cycle training may be effective in improving physical fitness and preventing metabolic diseases [3]. BMI is used to quickly and easily guide the classification of obesity, and the percentage of body fat is also evaluated by measuring the thickness of skin fold. Ojo Gideon's research found that there were differences in body composition variables between men and women, and women have a higher body fat rate than lower weight men. Further research in different populations in developing countries should help clarify ethnic differences in human body composition and develop functional reference standards [4]. Although the above scholars have conducted a more detailed study on the body fat rate of college students, the analysis methods limited to use are not comprehensive.

Many methods can be used to analyze and study the body fat rate of college students. Mill Ferreyra E, based on the traditional classification by body mass index, after proposing the biochemical activity of adipose tissue, carried out research to measure it. He used descriptive and prospective research methods to calculate body mass index and fat percentage with the obesity estimator and formula of Navarra University. He finally concluded that there was no significant difference between the results of the two formulas, which made it possible to calculate the percentage of fat in weight in primary medical and health institutions [5]. Ramirez-Velez Robinson studied and developed the body adiposity index (BAI), which was verified in the adult population. He investigated the performance of the BAI in estimating body fat percentage (BF%) among Columbia University youth. Among Colombian college students, the consistency between estimates of BF% based on BAI and those based on bioelectrical impedance analysis (BIA) was poor, so it was concluded that BAI is inaccurate in people with low or high body fat rate [6]. Ashtary-Larky Damoon evaluated the effects of ketogenic diets (KDs) on body mass (BM), fat mass (FM), fat-free mass (FFM), body mass index (BMI) and body fat percentage (BFP) of individuals undergoing resistance training (RT). It was finally observed that compared with non KDs, KDs were beneficial to BM and body fat (including FM and BFP) of RT treated individuals. However, sticking to KDs

may have a negative impact on FFM, and adding RT cannot improve this impact [7]. Trung Nguyen Nam conducted a cross-sectional study on 899 adolescents from Hanoi and Nanding in Vietnam in order to understand the change trend of body fat percentage of adolescents and determine the classification threshold of overweight and obesity by gender. Finally, compared with BMI, the percentage of body fat can more accurately evaluate whether adolescents are overweight or obese [8]. There have been many researches on physical exercise based on artificial neural network, but there are few papers that combine the artificial spirit with the network and the percentage of body fat of college students.

These scholars have conducted more research and analysis on body fat rate (including college students) from multiple perspectives. Although on the one hand, the methods used in this paper have not been extensively studied, and on the other hand, it also proves the feasibility of artificial neural network sports training in the field of college students' body fat rate research. On this basis, this paper combines the artificial neural network sports training to further carry out innovative research on the method of improving college students' body fat rate.

## 2. Body Fat Percentage of College Students

Body fat percentage mainly refers to the ratio of fat content to total body weight. It was mainly used for animals at the early stage, but recently people have paid more and more attention to their health. More scholars have innovatively combined the calculation of body fat percentage with the human body, and invented the measurement method of human body fat percentage and the standard range of different age groups which is convenient for people to conduct self-measurement and self-health management [9]. Meanwhile, the body fat percentage is also used to describe the physical conditions of athletes. Not all fats are bad, which contain essential fats, and there are also differences in fat requirements between men and women. This provides impetus for the follow-up research and encourages people to further study the percentage of body fat.

The traditional body fat percentage model is to calculate the proportion of weight and body fat by dividing fat content and body fat percentage by body mass index (BMI). This model has some limitations. BMI, as a simple weight standard, can reflect the health status of the human body. However, there are large differences among people in different regions [10]. Therefore, according to the data model, the differences of people's physique in different regions can be understood, so as to help people develop a more suitable lifestyle. This model can only reflect the difference between individual body fat percentage, but cannot reflect the influence of individual constitution difference on constitution percentage.

### 2.1. Sports Training Based on Artificial Neural Network

#### 2.1.1. Artificial Neural Network (ANN)

Artificial neural network is a new research hotspot in the field of artificial intelligence since the 1980s. Based on the perspective of information processing, the algorithm constructs a simple model by abstracting the neural network in the human brain through different connections [11]. Neural network is an operation model formed by many neurons connecting with each other. Recently, artificial neural network has been widely applied to intelligent robot, biology, medicine, economy and other fields, showing good intelligent performance.

Artificial neural network is mainly consists of three layers, namely input layer, hidden layer and output layer. In general, the data is input to the input layer, and then calculated through the hidden layer. Finally the result is output [12]. The specific operation diagram is shown in Figure 1:

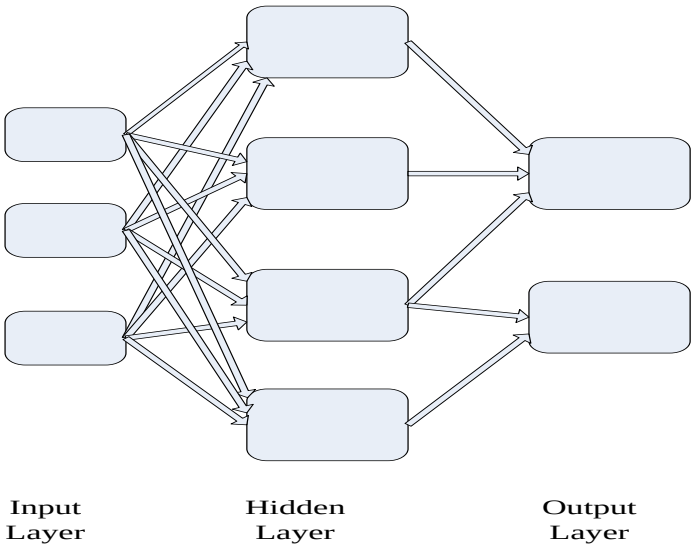


*Figure 1. Artificial neural network construction*

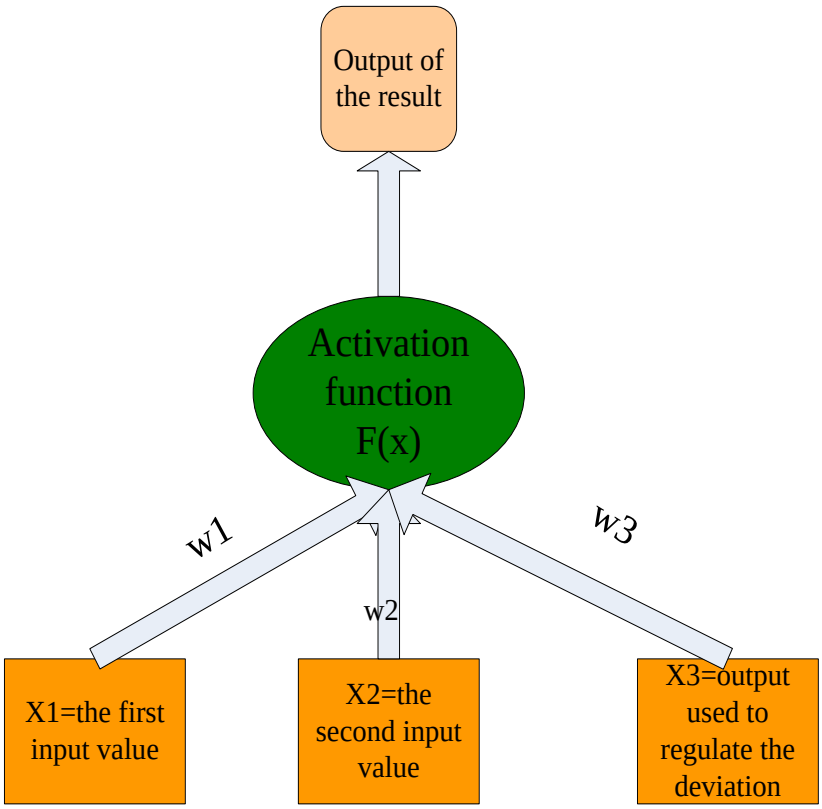


*Figure 2. Artificial neural network operation*

As shown in Figure 2, $x_1$-$x_3$ represent vectors, and $w_1$-$w_3$ are the weight vectors of each neuron synapse. The result is eventually incorporated into transfer function $f(x)$, which is usually a nonlinear function [13]. After calculation, the results are transmitted finally.

The specific propagation function is shown in Figure 3:

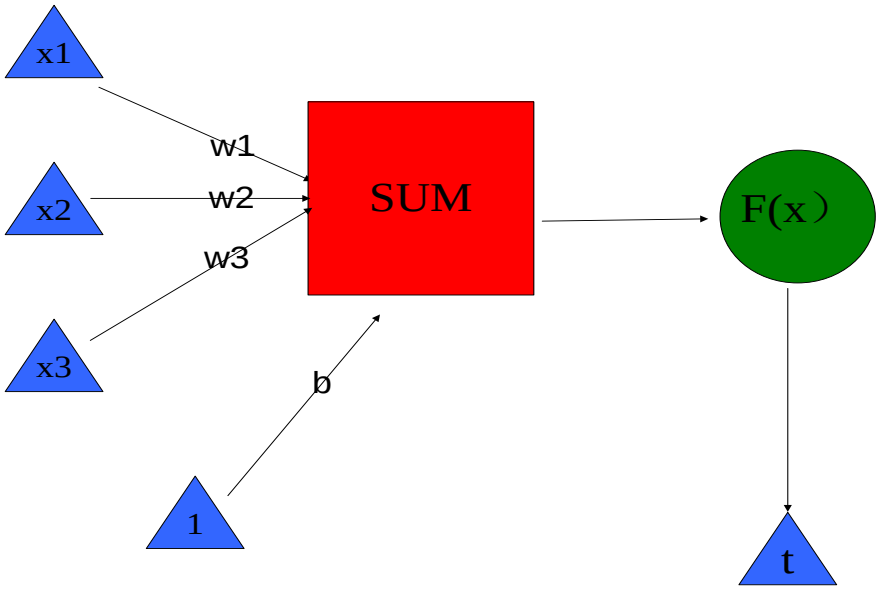


*Figure 3. The mode of propagation of neuron*

On the basis of Figure 3, b is offset, and t is neuron output. The formula is:

$$t = f(WA' + b) \tag{1}$$

It can be seen that the function of neurons is to obtain scalars by using nonlinear transfer functions on the inner product of vectors and weight vectors. On this basis, an n-dimensional vector space is divided into two directions (that is, determining the boundary), and the neuron determines which direction the vector is in the hyperplane. The W weight vector offsets the vector on the hyperplane, and the formula is as follows [14]:

$$Wp + b = 0 \tag{2}$$

### 2.1.2. Working Principles of Artificial Neural Network

ANN is a complex, nonlinear parallel parallel processing system, which simulates the complex processing structure of human body [15]. The general working mode of BP (back propagation) neural network is as follows:

(1) A network is initialized with appropriate structure, so that all adjustable parameters (weights and thresholds) are the minimum average distribution.

(2) Each sample is calculated as follows:

①Forward calculation: For neuron j in layer l, there is Formula 3:

$$v_j^l(n) = \sum_{i=0}^{T} w_{ji}^{(l)}(n) y_i^{(l-1)}(n) \tag{3}$$

In Formula 3, $y_i^{(l-1)}(n)$ is the working signal sent by neuron i in the previous layer (l-1 layers)(when i=0, $y_0^{(l-1)}(n) = -1$, $w_{j_0}^{(l)}(n) = \theta_j^{(l)}(n)$). If the activation function of neuron j is a Sigmoid function [16], then Formula 4 can be obtained:

$$y_j^{(l)}(n) = \frac{1}{1+\exp\left(-v_j^{(l)}(n)\right)} \tag{4}$$

And there are Formulas 5 and 6:

$$\varphi\left(v_{j(n)}\right)=\frac{\partial y_j^{(l)}(n)}{\partial v_j(n)}=\frac{\exp\left(-v_j(n)\right)}{\left(1+\exp\left(-v_{j(n)}\right)\right)^2} \tag{5}$$

$$\varphi\left(v_{j(n)}\right)=y_i(n)[1-y_i(n)] \tag{6}$$

②Reverse calculation:

For the output unit, there is Formula 7:

$$\partial_j^{(l)}(b)=e_j^{[L]}(n)o_j(n)\left[1-o_j(n)\right] \tag{7}$$

For the hidden unit, there is Formula 8:

$$\partial_j^{(l)}(n)\left[1-y_j^{(l)}(n)\right] \tag{8}$$

## 2.2. Establishment of Mathematical Model

The percentage of body fat is closely related to health. Through the research and analysis of this indicator, it is found that if the percentage of body fat of all students is within the normal range, there is no obvious problems in their physical fitness. On the contrary, there may be serious defects in their physical fitness [17]. Therefore, it is necessary to study this indicator in this case. Data analysis of body fat percentage index can help reveal this problem and provide scientific basis for improving it [18]. The mathematical model mainly includes KMO (Kampari Means One) model. According to the model established in the research results, it can be well revealed that this indicator has a serious impact on college students in all aspects. Therefore, this paper introduces the combination of artificial neural network and sports training into the study of college students' body fat percentage, so as to understand the relatively important influence of this factor on college students' body fat percentage [19].

## 2.3. Evaluation of Model Effect

In the prediction stage, applying the artificial neural network model, the sample data can be processed better, thus improving the model prediction effect [20]. This paper selected the support vector machine (SVM) prediction model as the prediction model of body fat percentage based on artificial neural network sports training, and used SPSS16.0 software to evaluate the effect of SVM model. The final error of the model was 1.156%, and the standard deviation was 0.218%, with the maximum mean of 1.503%. Among them, the average error was 0.196%, and the maximum mean was 1.355%, with the maximum variance of 0.295%. The overall error was small, which better reflected the best result of the BMI scoring method. In this paper, by using support vector machine to predict, it can be found that the value decreased with time, and the decrease was large with time.

# 3. Prediction of Body Fat Rate Model of College Students

## 3.1. Description of Characteristics

Before the experiment, the percentage of body fat of all students in three grades randomly selected from a university was tested. 50 students with similar body fat percentage were selected in three grades. In the three grades, 25 males and 25 females were selected respectively for unified physical training and BMI monitoring after training.

### 3.2. Prediction and Evaluation of Body Fat Percentage of College Students

This paper used support vector machine (SVM) prediction model to predict the percentage of body fat. Because the prediction accuracy of the model was very high and good data results could be obtained, the SVM prediction model method in this paper was used to establish the model. The SVM prediction model combines linear regression and random number regression and calculates the fitting degree of the difference between the predicted objective functions to determine the probability on which the regression results are based. The specific method was as the follows: First 8 data sets were selected; then the optimal combination of 8 data sets was used to obtain the predicted objective function and its fitting function; linear regression and Markov fitting were conducted respectively. After these two methods were calculated, the random number was used for simulation calculation to predict. When the model achieved a good fitting effect in 8 data sets, it meant that the model was in line with expectations; otherwise, the model was unqualified. Next, the randomly generated prediction variables were used to simulate different indicators to get the final prediction results, so as to further test the fitting effect of the model.

First, the basic linear regression simulation method was used to predict and analyze it, and finally Figure 4 was obtained:

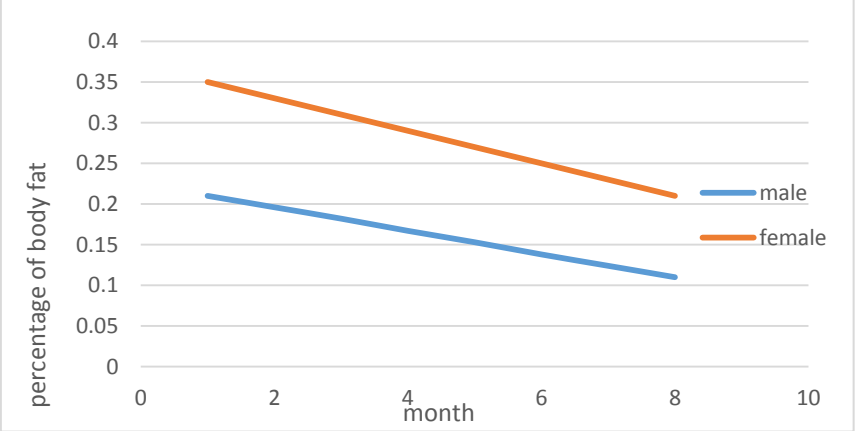


*Figure 4. Linear regression prediction of percentage body fat for college students (1-8months)*

First of all, it can be roughly seen that the percentage of body fat of college students had been declining with the growth of time in 8 months, and the decline rate was relatively slow. This is a simulated prediction using the traditional linear regression method. Next, the SVM model was used to predict the body fat percentage of college students using artificial neural network technology. The prediction chart is shown in Figure 5:

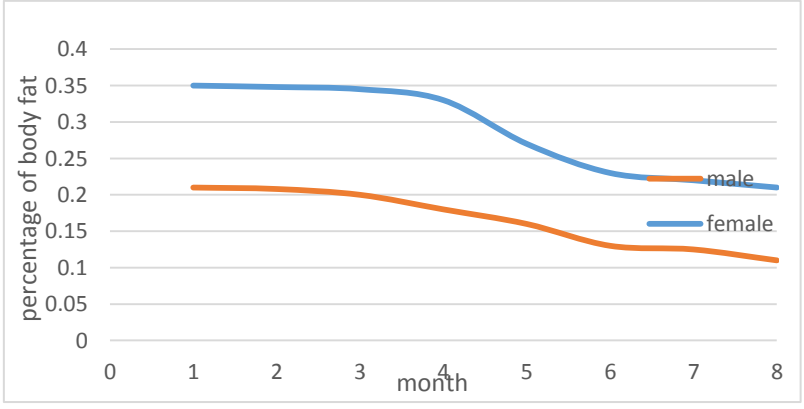


*Figure 5. SVM model for predicting body fat percentage of college students (1-8 months)*

It can be seen from Figure 5 that the percentage of body fat after physical training intervention had been significantly reduced. According to the trend in Figure 5, it can be seen that the percentage of body fat of college students before training is different from that after training, and both are within the normal range. During the period from 1 to 8 months, the percentage of body fat of male and female students selected in the experiment gradually decreased after physical training. At the early stage of training, the percentage of body fat of males was close to 0.21 and declined slowly. As the physical training continued, the decline rate gradually increased, and finally became slow and gradually close to 0.11 indefinitely. The percentage of body fat of female students also showed the same trend, with an initial BMI of about 0.35, gradually approaching 0.21. According to the above conclusions, it can be concluded that the lower the percentage of body fat after training, the better for the physical health of college students, and as the training cycle and times increase, the percentage of body fat gradually decreased.

As shown in Figure 4 and Figure 5, the prediction using linear regression method and the prediction using support vector machine model showed a similar trend, that is, after physical training, the percentage of body fat of college students showed a downward trend over time. However, the simulation of linear regression method was relatively rough, because according to the calculation of experimental data, the two did not show a strict linear relationship. Only one experiment could not draw a correct conclusion. Next, the data of 36-43 months were investigated to find whether the percentage of body fat of college students showed the same trend.

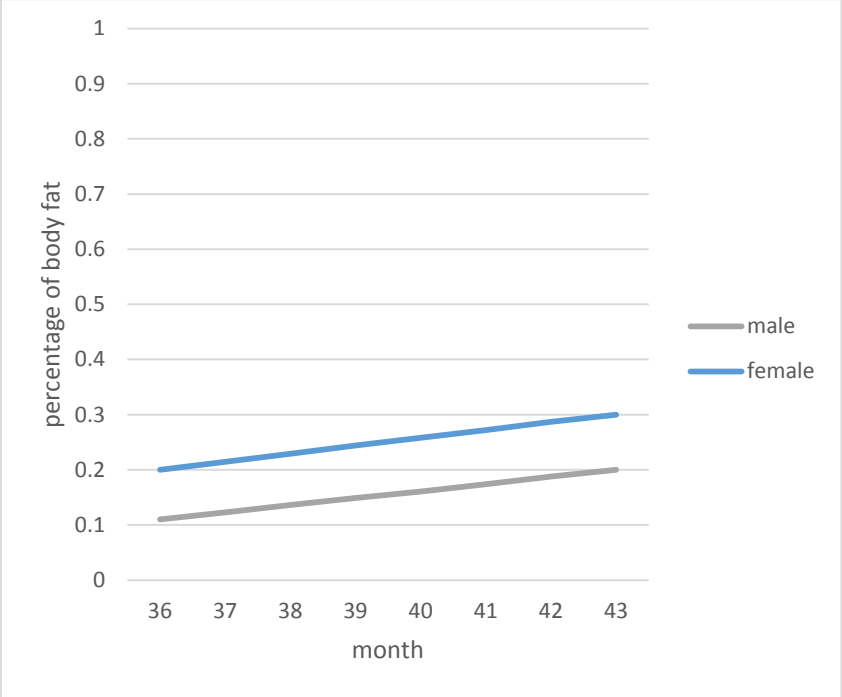


*Figure 6. Linear regression prediction of percentage body fat for college students (36-43months)*

It can be seen from Figure 6 that at 36-43 months, the percentage of body fat of college students presented a linear trend that was completely opposite to the previous one, which meant that the percentage of body fat of college students would not simply increase over time without a bottom line decreasing, but would eventually rebound to the bottom, showing a slow growth trend. Next, this paper applied the support vector machine model to predict the percentage of body fat of college students at 36-43 months. The results are shown in Figure 7.

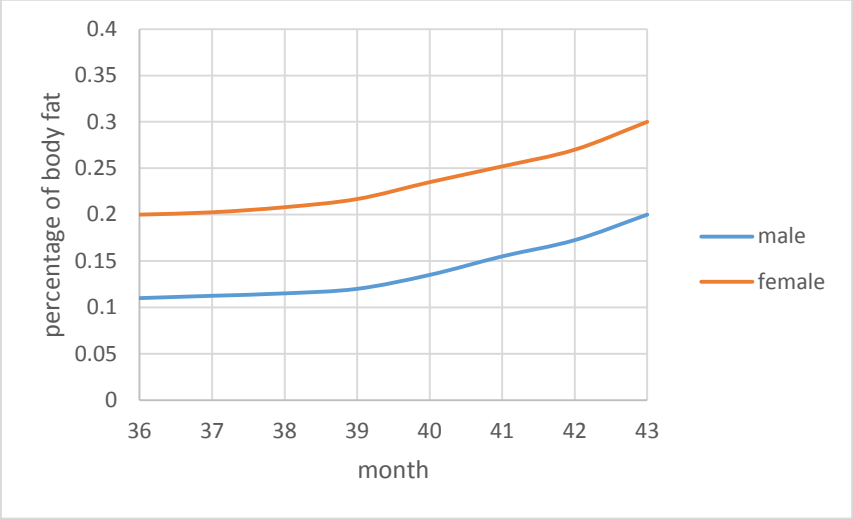


*Figure 7. SVM model for predicting body fat percentage of college students (36-43months)*

Although the sports training in the first eight months had a great effect on the reduction of body fat rate of college students, it did not mean that the same trend would be shown if they persisted for a long time. It can be seen from Figure 7 that in the 36th to 43rd months of physical training, the percentage of body fat of college students did not decrease but increased, showing a slow rising trend, and the difference in percentage of body fat was small, rising slowly. Then, the percentage of body fat of college students who had undergone 36-43 months of physical training was studied and analyzed. This paper found that when the percentage of body fat of college students gradually approached the normal value, it turned again, with a growing trend. Males gradually showed an upward trend when it dropped to 0.11, and the growth rate was small, while females gradually increased from about 0.2.

### 3.3. Prediction and Evaluation Results

According to the comparative analysis, the following results are mainly obtained:

(1) At the end of the high-intensity training cycle, not only the training effect of college students is poor, but also the physical condition of college students is poor, and the physical fitness is also poor. This is because most students' training mode is intermittent, which lasts for a short time, and muscle soreness is easy to occur after exercise. After the intervention of physical training, the fat content in the body of college students is significantly reduced. At the same time, less heat is generated after exercise, which is easy to cause incomplete fat burning. This can also stimulate the body muscle to produce more metabolic waste, thereby improving the proportion of muscle and fat.

(2) After 8 months of training cycle, the metabolism of college students gradually gets better in the process of high-intensity training, which can significantly reduce the fat content in the body, but muscle soreness and other adverse phenomena may occur in the whole exercise cycle. After 3 months, the low intensity trainers have started to slowly increase their physical energy consumption during fitness. During the whole exercise process, the burning rate of muscle and fat increases, the degree of muscle soreness and the weight gain decreases significantly. Therefore, muscle soreness is significant for the reduction of the percentage of body fat. When the exercise cycle is prolonged, the body fat starts to decompose, and the muscle soreness may be relieved. After a period of high-intensity exercise, muscle strength can become stronger. At this time, the fat and muscle inside the body of the high-intensity trainer are easier to decompose, and the fat content is more balanced. This can make the percentage of body fat decrease more, and there is no significant difference in the

percentage of body fat between the two training interventions at 8 months and 43 months.

(3) After 36-month training, the BMI of college students has risen, and a lot of fat has accumulated in their bodies and it is difficult to get rid of them. Therefore, in the process of exercise, it is necessary to constantly control weight and not increase the amount of exercise too much. Therefore, sports training must be carried out regularly. During the fitness training, the appropriate amount of exercise should be maintained, and the time and number of exercises should be reasonably arranged each time. Training twice a week not only allows college students to have more time to train, but also can increase the number and types of fat tissues consumed by students and avoid the accumulation of fat in the body, so as to reduce body fat.

## 4. Discussion

(1) The change trend of body fat percentage is analyzed using the support vector machine model, and the support vector machine model is used to obtain the decline trend of body fat percentage through data analysis (as shown in Figure 5). Figure 5 showed that the decreasing trend of body fat percentage caused by physical training is controlled and slowed down. It can also be known from Figure 5 that the percentage of body fat presents a downward trend within three years. As the percentage of body fat shows a downward trend, it can be found that college students need to carry out more systematic physical training to increase muscle mass to effectively reduce the percentage of body fat. After 36 months, as the amount of physical training increases, it shows that college students need to carry out long-term physical training to enhance muscle mass and reduce fat content to reduce the body heat demand and maintain weight. For college students with a high percentage of body fat, a long time of physical training may help reduce the body fat rate and effectively alleviate the health problems caused by the high body fat rate, such as the reduction of BMI, the decline of lower limb mass, and the obvious decline of body fat level. With the increase of physical training time, the students' body fat level can be reduced, while the body fat may continue to increase, and their fat metabolism ability can also be improved.

(2) Through physical training, college students' physical quality can be effectively improved, and problems such as high body fat rate and insufficient muscle mass can be alleviated. The follows are found from the discussion on the mechanism of physical training: As people's living standards continue to be improved, their requirements for healthy sports are also constantly improving. Fitness has become the first choice for many young people to keep fit. Contemporary college students generally like to stay at home, which leads to their own bad habits and behavior. Moreover, at present, college students are mainly sedentary and lack of certain sports. They have little time to exercise, and they are always unable to go home on time for various reasons every night or weekend, so they may not pay attention to the rules of life. The students lack enough exercise, which leads to the decline of physical quality, insufficient muscle mass, high fat rate, obesity, rough skin, low immunity and other problems. This paper believes that through the rational use of physical training, students' physical fitness can be effectively improved and the problems of high body fat rate and insufficient muscle mass can be alleviated. Then it puts forward some suggestions to improve college students' unhealthy behavior habits and exercise habits through physical training, and promote the implementation of healthy sports methods. As contemporary college students are in the stage of physical development and personality shaping, their enthusiasm and intensity of participating in sports can also be correspondingly improved. However, due to the heavy burden of courses in contemporary universities and the lack of reasonable exercise time and high learning pressure, students feel tired due to the lack of exercise time, which results problems such as fat accumulation in the body. This is also a problem that contemporary college students need to pay attention to in the future.

(3) The body fat rate of college students should be optimized and their constitutions need to be improved. Contemporary college students have become the backbone of the development of modern society. Having strong physical quality has become necessary for the progress and development of modern society. Therefore, it is urgent to optimize the body fat ratio of college students, and physical training can alleviate this problem. Physical training can accelerate the coordination between human adipose tissue and muscle cells to improve the utilization rate of human adipose tissue. Muscle volume and physical activity ability have the greatest impact on the body fat percentage. With the growth of people's age, the amount of human muscle and physical fitness are declining year by year. It means that human muscle loss is fast, and even cannot provide enough training and exercise time to maintain their own blood circulation, which may lead to muscle fatigue or functional decline. Therefore, physical training is vital to optimize the college students' body fat rate, which can not only improve health problems, but also improve human movement ability and coordination ability.

## 5. Conclusion

Using the support vector machine prediction model, this paper has analyzed the performance of the prediction model. The outcome indicated that the prediction model can well predict the change trend of body fat percentage of college students in a period of time. Through the analysis and comparison of the prediction results of the support vector machine model, it can be seen that compared with the actual situation, the change trend of the body fat percentage of contemporary college students predicted by the support vector machine model obviously came out to be better than the prediction results of the traditional regression model. On the basis of the research on the change trend, influence scope, influence effect and related factors of the current college sports training on the percentage of body fat of college students, this research used a new method to study the influence of the change trend of the percentage of body fat of college students on their own constitutions, and then put forward suggestions that sports training can make the physical quality of college students better, so as to alleviate the problems of high body fat rate and insufficient muscle mass, and optimize the body fat rate. Due to the incompleteness of the model and data used in this paper, the research on the percentage of body fat of college students in this paper still has some limitations, and further research is needed to obtain more scientific conclusions.

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## Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

## Conflict of Interest

The author states that this article has no conflict of interest.

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