

## Research Article

# Modeling Analysis of the Relationship between Adolescent Aerobic Exercise and Obesity Reduction Based on Deep Learning

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In order to explore the modeling analysis of the relationship between adolescent aerobic exercise and obesity reduction, the relationship modeling method of deep learning algorithm is proposed. This study integrates deep learning algorithms and first uses the changes in body shape, weight, BMI index, body fat, body circumference, and other indicators of adolescent obese before and after aerobic exercise as the initial pheromone distribution matrix and introduces random evolution factor and evolutionary drift threshold to establish the objective function of aerobic exercise to reduce adolescent obesity. It also explains the constraint conditions that aerobic exercise has to meet in the reduction of adolescent obesity and introduces particle algorithm to establish a model of optimal aerobic exercise to reduce adolescent obesity. The simulation results show that, under the same number of experiments, the advantages of this method are more obvious. On the overall level, the average modeling error of this method is about 0.053%, while the average of the traditional method is about 0.186%, indicating that the method can reduce the error control within a reasonable range. It proves that deep learning can effectively reflect the modeling analysis of the relationship between adolescent aerobic exercise and obesity reduction.

## 1. Introduction

While economic development improves people's living standard, it also brings some disadvantages to people, such as the continuous expansion of adolescent obesity. Because adolescent health affected China's overall health level, therefore, how to effectively improve adolescent health became the field of medicine and sports fields; the main problems to be settled urgently and aerobic exercise on the relationship of the adolescent obesity to reduce modeling method can analyze the factors of the formation of adolescent obesity, and obesity harm caused by different factors on the youth. The model of the relationship between aerobic exercise and obesity reduction in adolescents has been established, which provides a strong basis for improving the physical health of adolescents and is the fundamental way to solve the above problems, which has attracted the attention of many experts and scholars. Due to the profound development significance of the modeling method of the relationship between aerobic exercise and the reduction of

obesity in adolescents, it has also become the focus of research in the industry, which has been widely concerned, and many good methods have emerged.

Body fat rate is an important indicator of the degree of obesity, and it also has a significant impact on human health. Too high or too low means are more likely to suffer from chronic diseases. Moreover, the change in the body fat rate is significantly greater than the change in body weight. This is due to the lack of physical activity in obese children and adolescents. During exercise, muscle movement increases muscle volume and weight to varying degrees [1]. As shown in Figure 1, a large number of studies have proved that regular and planned aerobic exercise can improve the body's blood lipid metabolism and has a very positive effect on the prevention and treatment of cardiovascular diseases. There is a complete set of mechanisms for fine-regulating glucose metabolism in the normal human body, which can maintain blood sugar in a stable range (3.89 ~ 6.11 mmol/L) without major fluctuations. This is mainly due to the regulation of hormones. The main hormones involved in regulating blood

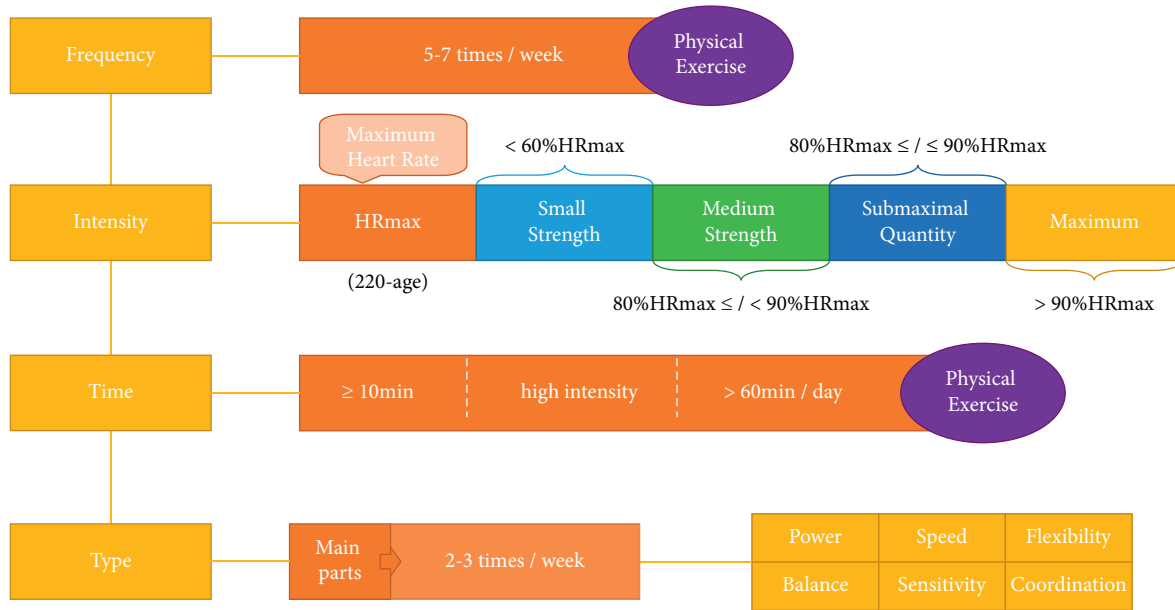


FIGURE 1: The relationship between aerobic exercise and obesity reduction.

sugar are insulin and glucagon. By regulating the activity of key enzymes in cells, these hormones not only coordinate the metabolism of sugar, amino acids, fats, etc., but also coordinate the metabolism of organs such as liver, muscle, and adipose tissue to adapt to changes in energy demand and fuel supply in the body [2].

## 2. Literature Review

Rahmatallahpur and Rostami first proposed the use of a time-lag differential equation model to describe the changes in blood glucose and insulin, and very good results were obtained in both mathematical and physiological senses [3]. Then, Fujie et al. carried out on the basis of the above model generalized and obtained a more general model [4]. This model covers another special delay differential equation model proposed by Kim and Jung [5] and the IVGTT model with a specific functional form proposed by Xiang et al. Later, some scholars have successively studied the insulin secretion time lag and the effect of insulin on the liver's decomposition of liver glycogen. There is a blood glucose-insulin metabolism model with multiple time lags [6]. Slusher et al. introduced the parameters of the mathematical model based on the physiological process. The effect of aerobic exercise on the blood sugar of different groups of people, and the comparison of the blood sugar of T1DM and T2DM patients and healthy people whether aerobic exercise is performed confirms that aerobic exercise can effectively prevent the occurrence of diabetes, but it has not been explored based on the individual differences of patients. The required aerobic exercise intensity and insulin injection strategy [7]. In terms of data driving, Killer et al. use heart rate instead of energy expenditure as the input of the blood glucose dynamic model for the first time, quantifying the impact of aerobic exercise on individuals with T1DM. In the process of clinical trials, when the heart rate exceeds 125% of

the normal heart rate, it is considered that aerobic exercise has occurred. It is necessary to manually turn off the input of the insulin pump to wait for the heart rate to return to a normal level. However, patients with diabetes usually have cardiovascular complications, which will affect the heart rate, and there is a time lag between the change of heart rate and the occurrence of aerobic exercise [8]. In response to the above shortcomings, Mora-Rodríguez et al. proposed to replace the heart rate with an accelerometer as a model. Input can accurately determine the moment of aerobic exercise, but describing the intensity of aerobic exercise requires further fusion of other types of sensors and extracting appropriate features. Although the above models have achieved some results, most of them stay in qualitative analysis of the impact on blood sugar caused by aerobic exercise. There are few quantitative analysis models of blood glucose changes in diabetic patients under different aerobic exercises [9]. Pedersen et al. proposed a fuzzy multiobjective genetic optimization algorithm to model the relationship between aerobic exercise and the reduction of adolescent obesity. This method first obtains the fuzzy influencing factors of aerobic exercise on the physical health of obese adolescents, uses this factor to extract the change characteristics of obese adolescents' physical fitness index, and establishes a model for aerobic exercise to reduce obesity in adolescents. This method is relatively simple, but there is a problem of large modeling errors [10]. Aoike et al. discussed neural network and fuzzy theory modeling the relationship between aerobic exercise and obesity reduction in adolescents. Multilayer feedforward neural network is adopted to establish the obese adolescents, the method before and after aerobic exercise on the body configuration, fasting blood glucose, blood lipid and blood insulin, and serum index contrast model, such as variation characteristics before and after extraction obese adolescents are aerobic exercise; based on the characteristics, a model on the relationship between

the adolescent obesity was established to reduce aerobic exercise. This method has low time complexity, but when the current algorithm is used to build the model, it is unable to determine the causes of adolescent obesity in detail, and there is a problem of large modeling error [11]. Duran et al. focused on the modeling method of the relationship between aerobic exercise and adolescent obesity reduction based on least square support vector machine. In this method, the least square support vector machine algorithm was used to classify the causes and harms of adolescent obesity. On this basis, the model of reducing adolescent obesity by aerobic exercise was established according to the different causes of adolescent obesity. This method has high establishment accuracy, but the modeling process is tedious and time-consuming [12]. However, the traditional methods cannot obtain the changes of various indicators of obese adolescents before aerobic exercise, which reduces the accuracy of the model. An improved ant colony algorithm was proposed to model the relationship between aerobic exercise and adolescent obesity reduction. Nan and Kesen propose an improved ant colony algorithm-guided aerobic exercise method. Firstly, the changes of body shape, weight, BMI, body fat, body circumference, and other indicators before and after aerobic exercise in obese adolescents are used as the initial pheromone distribution matrix, and random evolution factors and evolutionary drift thresholds are introduced to establish the goal of reducing obesity caused by aerobic exercise in adolescents' features. The experimental results show that the method can control the error within a reasonable range, which proves that the improved ant colony algorithm can have a good correlation with the method of aerobic exercise [13].

Based on the current study, an in-depth learning algorithm-based relationship modeling approach is proposed to study the model analysis of the relationship between aerobic exercise and obesity reduction in adolescents. Integration into the in-depth training algorithm uses changes in body shape, weight, BMI index, body fat, body circumference, and other parameters in obese adolescents before and after aerobic exercise, the first matrix of pheromone distribution, random evolution factors, and evolutionary transitions. The threshold defines the objective function of aerobic exercise to reduce obesity in adolescents and explains the limitations required for aerobic exercise to reduce obesity in adolescents. Particle algorithms have been introduced to create optimal aerobic exercise models to reduce obesity teenagers.

### 3. The Relationship between Adolescent Aerobic Exercise and Reducing Obesity

*3.1. Principles of Relationship Modeling.* When modeling the relationship between aerobic exercise and adolescent obesity reduction, first collect the various factors that contribute to adolescent obesity, calculate the weight coefficients of each factor that are detrimental to adolescent health, and establish a model of aerobic exercise relationship. Aerobic exercise provides communication limitations that reduce adolescent obesity, calculates the goal function, uses this function to

solve a problem, creates a model, and explains the specific steps in detail as follows.

Assuming that  $Q_s$  represents the main cause of obesity and  $X_i$  and  $w_i$  represent the psychological and physiological harm caused by obesity to adolescents, the following formula is used to calculate the weight coefficient of each obesity hazard factor to the health of adolescents:

$$q_h = \frac{(Q_s \cdot \lambda)}{X_i \cdot w_i} \times \varepsilon(Q \cdot \beta), \quad (1)$$

where  $\varepsilon$  represents the number of fat cells in the body,  $Q$  represents the period when the fat content in the cells of the obese young people increases, and  $\beta$  represents the calories of food consumed by the obese young people. To establish a relationship constraint model for aerobic exercise to reduce adolescent obesity, we use the following formula to express

$$Q_{rij}(t+n) = \frac{(1-\rho) \cdot Q_{rij}(t)}{q_h}, \quad (2)$$

where  $\rho$  represents the changes in body shape and body composition of obese youths before and after exercise and  $Q_{rij}$  represents the comprehensive risk factors of cardiovascular and other pathological changes in obese youths.

Assuming that  $\tau_{ij}(t+1)$  represents the constraint condition of the relationship between aerobic exercise on the reduction of adolescent obesity and TP represents the state of adolescent obesity, the following formula is used to calculate the relationship objective function of aerobic exercise on the reduction of adolescent obesity:

$$Q^* = Q_{rij}(t+n) * \frac{FN}{TP} \cdot FP\tau_{ij}(t+1), \quad (3)$$

where FP represents the blood pressure changes of obese adolescents before and after exercise and FN represents the decrease in waist and hip circumference of obese adolescents after exercise. However, traditional methods cannot obtain the changes of various indicators of obese adolescents before aerobic exercise, which reduces the accuracy of the model [14]. Therefore, a modeling method for the relationship between aerobic exercise with improved deep learning algorithm and the reduction of adolescent obesity is proposed.

#### 3.2. Relational Modeling Method

*3.2.1. Obtaining the Objective Function of the Relationship between Aerobic Exercise and the Reduction of Adolescent Obesity.* In the process of optimizing the modeling of the relationship between aerobic exercise and the reduction of adolescent obesity, the deep learning algorithm first uses the changes in the body shape, weight, BMI index, body fat, body circumference, and other indicators of adolescent obese before and after aerobic exercise. As the initial pheromone distribution matrix, random evolution factors and evolutionary drift thresholds are introduced to establish the objective function, and the constraint conditions that aerobic exercise needs to meet for the reduction of adolescent obesity are explained. The specific steps are detailed as follows.

Assuming that  $q_{ij}$  represents the body shape information change factors of obese adolescents before and after aerobic exercise,  $A$  represents the influence of obesity on the amount of activity of adolescents, and  $\partial_{ij}$  represents the change factors of BMI index before and after aerobic exercise of obese adolescents, which are combined with the use of deep learning algorithms, we establish the initial distribution matrix of pheromone represented by  $\eta_{ij}$ :

$$\eta_{ij} = \frac{(q_{ij}, M_{ij}) \times A}{(\partial_{ij}, d_{ij}) \times R_{ij}} \times K_{ij}, \quad (4)$$

where  $M_{ij}$  represents the energy accumulation state of obese adolescents before and after exercise and  $d_{ij}$  represents the change factors of low-density lipoprotein secretion information before and after exercise of obese adolescents.

In conclusion, in the process of optimal modeling of reducing obesity caused by aerobic exercise, the ant colony algorithm integrated with the ant colony algorithm firstly used the changes of body shape, weight, BMI, body fat, body circumference, and other indicators of obese adolescents before and after aerobic exercise as the initial pheromone distribution matrix. Random evolutionary factor and evolutionary drift threshold were introduced to establish the objective function of reducing adolescent obesity by aerobic exercise, and the constraint conditions of reducing adolescent obesity by aerobic exercise were explained, which provided the basis for establishing the model.

*3.3. The Relationship Modeling between Aerobic Exercise Based on Particle Algorithm and Adolescent Obesity Reduction.* In the process of optimizing the modeling of the relationship between aerobic exercise and the reduction of adolescent obesity, based on the objective function under the constraint conditions that aerobic exercise has to meet for the reduction of adolescent obesity given by the above formula, the particle algorithm is introduced to establish the optimal model. The specific steps are detailed below.

It supposes that  $X_i = (x_{i1}, x_{i2}, \dots, x_{iD})$  represents the first particle, and based on  $\Delta\tau_{ij}^k$  obtained by the above formula, the best position it has experienced (with the best fitness value) is expressed as

$$P_i = \frac{(p_{i1}, p_{i2}, \dots, p_{iD})}{X_i = ((x_{i1}, x_{i2}, \dots, x_{iD}))} \times \Delta\tau_{ij}^k, \quad (5)$$

where  $p_{i1}$ ,  $p_{i2}$ , and  $p_{iD}$ , respectively, represent the historical optimal position that the particle has passed through.

Assuming that  $g_{best}$  represents the index number of the best position passed by all particles in the group, the velocity of particle  $i$  is expressed by the following formula:

$$V_i = \frac{g_{best} \cdot p_i}{(v_{i1}, v_{i2}, \dots, v_{iD})}. \quad (6)$$

For the  $d$ th dimension of each generation of particles, we use the following formula to iterate

$$v_{id}(t+1) = v_{id}(t) + c_1 r_1 [p_{id} - x_{id}(t)] + c_2 r_2 [p_{gd} - x_{id}(t)], \quad (7)$$

where  $c_1$  and  $c_2$  represent normal numbers, which are two random numbers that vary in the range of  $[0, 1]$ ,  $t$  and  $t+1$  are algebras,  $v_{id}$  represents the velocity of each particle in the  $d$  dimension,  $i$  represents the particle number,  $d$  represents the dimension,  $r_1$  and  $r_2$  represent a random number between 0 and 1,  $p_{id}$  represents the best position of each particle so far,  $p_{gd}$  represents the best position of all particles so far, and  $x_{id}$  represents the particle's current location [15].

Use the following formula to establish the relationship model of aerobic exercise on the reduction of adolescent obesity:

$$\min f(x) = \frac{v_{id}(t+1) \times V_i}{X_i}. \quad (8)$$

## 4. Simulation Results and Analysis

The subjects of the experiment came from young people who voluntarily participated in aerobic exercise to lose weight. There were 100 obese adolescents with an average age of 13 to 18 years old. Among them, 50 were male and female, and they performed low-intensity long-term aerobic exercise for 4 weeks. Before the experiment, the parents of the subjects need to sign an informed consent form.

- (1) Research design: in all trials examining the effects of aerobic exercise on body fat percentage in obese adolescents, the duration of intervention was not less than 4 weeks. Studies of other exercise interventions were excluded from the literature.
- (2) Research object: obese adolescents aged 13 to 18 (body fat percentage >30%), different literature studies, and different research objects.
- (3) Outcome measurement indicators: the main index was the change of body fat percentage of obese adolescents before and after aerobic exercise intervention.
- (4) Intervention measures: all exercise interventions in the literature were aerobic [16].

*4.1. Accuracy Comparison of Different Modeling Methods.* The improved algorithm and other algorithms were used to carry out aerobic exercise to reduce the obesity modeling experiment of adolescents and observe the changes of adolescents' body shape and body composition before and after aerobic exercise. The statistical results of the two different algorithms are compared with the average changes in adolescent body shape and body composition before and after actual aerobic exercise, and the comparison results are used to measure the comprehensive effectiveness of the two different models [17, 18]. The comparison results are shown in Tables 1 and 2.

Analysis of Tables 1 and 2 shows that when using the method in this study to analyze the changes in the index values of obese adolescents before and after aerobic exercise, the changes in the indicators obtained by the method in this study are basically consistent with the actual values, while

TABLE 1: Changes in index values before exercise by different methods.

Index	Improved ways	Actual value	Traditional ways
Height (cm)	175	175	175
Weight (kg)	112.5	112.5	112.5
BMI	36.54	36.54	36.54
Waist circumference (cm)	131.4	131.4	131.4
Hips (cm)	142.1	142.1	142.1
Body fat rate (%)	41.6	41.57	41.57
Fat mass (kg)	14.12	14.11	14.11

TABLE 2: Changes in index values after different methods of exercise.

Index	Improved ways	Actual value	Traditional ways
Height (cm)	171.3	171.3	169.4
Weight (kg)	112.5	112.5	102.5
BMI	32.74	32.74	22.74
Waist circumference (cm)	121.4	121.4	131.4
Hips (cm)	114.5	114.5	124.5
Body fat rate (%)	41.6	41.57	41.57
Fat mass (kg)	8.75	8.75	16.11

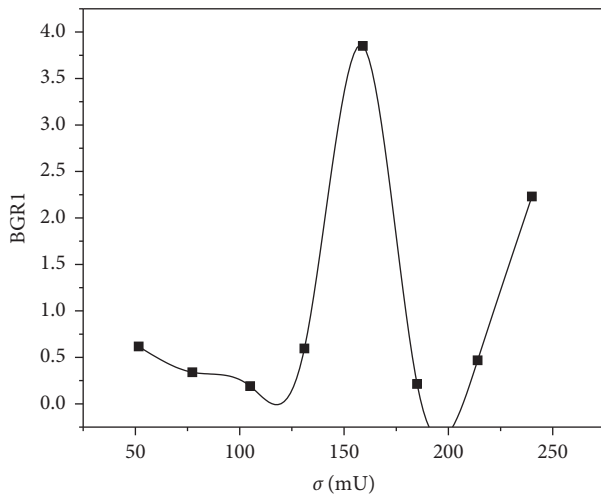


FIGURE 2: Group A under moderate-intensity aerobic exercise.

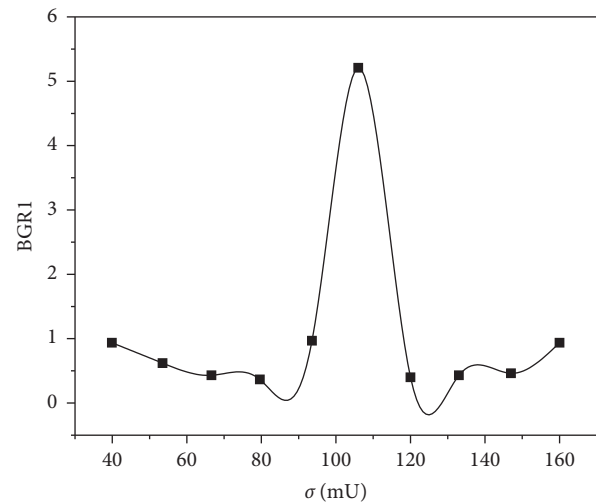


FIGURE 3: Group B under moderate-intensity aerobic exercise.

the traditional method and the actual value are quite different. The modeling method in this study has high accuracy [19, 20].

In Figures 2 and 3, under moderate-intensity aerobic exercise, the BGRI indicators faced by patients in group A and B under moderate-intensity exercise decreased from 0.9672 and 1.3889 to 0.3397 and 0.3559, respectively, which not only greatly reduced the patient’s economy burden but also reduces the negative effects of drugs and reduces the risk of blood sugar in patients [21, 22].

As shown in Figures 4 and 5, there are certain differences in the amount and extent of fat loss in different parts of the body in different environments. In addition, this study found that the percentage of body weight loss in normal environment is more than 80% [23–26].

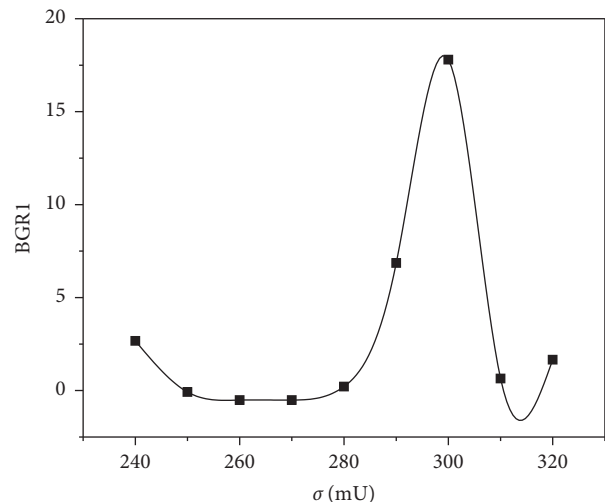


FIGURE 4: Group A under low-intensity aerobic exercise.

4.2. Error Comparison of Different Modeling Methods. The modeling experiment of the relationship between aerobic exercise and the reduction of adolescent obesity was carried



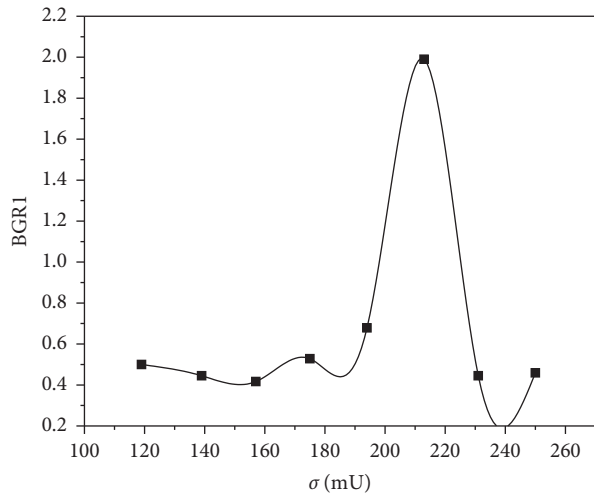


FIGURE 5: Group B under low-intensity aerobic exercise.

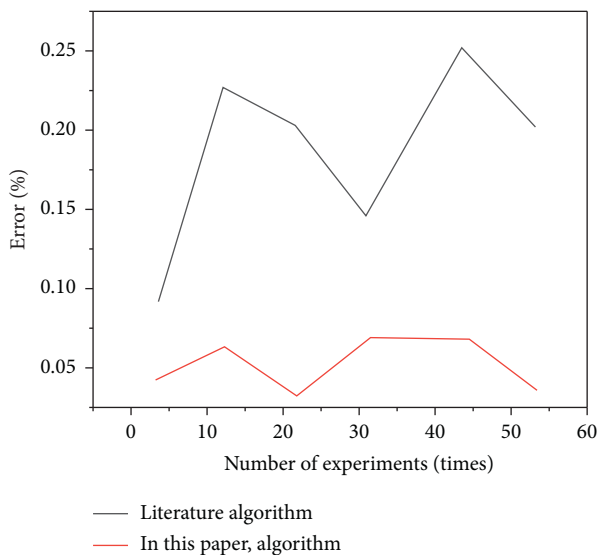


FIGURE 6: Comparison of modeling errors of different algorithms.

out by using the improved algorithm and other algorithm, respectively. Under different experiment times, compare the error rates of two different algorithms to establish a model for reducing adolescent obesity by aerobic exercise. Analysis of Figure 6 shows that, under the same number of experiments, the modeling error of this method is much smaller than the traditional methods in other algorithms. With the continuous increase of the number of experiments, the advantages of this method are more obvious. From the overall level, the modeling error of the method in this study is about 0.053% on average, while the traditional method is about 0.186% on average, indicating that the method in this study can control the error within a reasonable range.

## 5. Conclusion

When using the method in this study to analyze the changes in the index values of obese adolescents before and after aerobic exercise, the obtained index changes are basically

consistent with the actual value, but the traditional method is far from the actual value. The average modeling error of the method in this study is about 0.053%, while the average of the traditional method is about 0.186%. The simulation results show that the improved model established in this study can analyze the relationship between aerobic exercise and the reduction of adolescent obesity.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The author declares no conflicts of interest.

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