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Research Article

Construction of Regression Equation for Maximum Oxygen Uptake Recognition of Respiration and Heart Rate in Exercise Training

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The main test objective of cardiopulmonary function is the maximum oxygen uptake. In order to identify the maximum oxygen uptake, this study constructs the maximum oxygen uptake recognition regression equation of exercise training respiration and heart rate. Students were selected from high school and randomly assigned to modeling and experimental groups. In the first phase, the general physical characteristics of more than 200 people and whether the vehicle load has increased are directly checked, relevant information is collected, and the indicators, such as age, height, weight, body weight, heart rate, and regression equation, are compared. Predictive model: the results show that the F value in Model 5 is 102.948, much less than 0.000, and much less than 0.001, indicating maximum load, weight, sex, maximum heart rate, BMI, and maximum oxygen uptake. Therefore, the predictive models used to determine body weight, maximum load, sex, maximum heart rate, BMI independent variable, and VO_2max as a dependent variable were reliable. The results of the Durbin Watson test are 1,639, indicating that the independence of the terminology of the recognition error in the regression model is good.

1. Introduction

Aerobic endurance is the quality basis for cyclists to achieve excellent results. Monitoring the changes of some aerobic endurance indicators of cyclists can effectively guide and supervise training [1]. VO_2 max is the amount of oxygen a person receives per unit of time at peak cardiorespiratory fitness and muscle oxygen utilization during long-term exercise involving many muscle parameters. Maximal oxygen uptake has also become an important index to evaluate cardiopulmonary function and aerobic capacity and has been paid attention to in competitive sports and mass sports. At present, there are two measurement methods, namely, direct measurement and indirect measurement [2]. However, both methods have some problems and limitations. The direct measurement data are reliable and objectively reflect the aerobic working ability. However, not all people can tolerate this stimulation in the direct test. The experimental instruments are expensive and the methods are complex [3].

Indirect measurement is simple, easy, economical, and fast, but the measurement error is large [4]. At present, based on the continuous development of artificial intelligence and technological advances, the process of constructing the regression equation for respiration and heart rate VO_2 max in exercise is shown in Figure 1 [5].

2. Literature Review

To solve this research problem, Martufi et al. found that there was no significant statistical difference between ventilation threshold and arterial blood lactate threshold in VO_2, VO_2max percentage, VE, HR, and R values, and there is a significant correlation between the two starting points ($r = 0.886$, $P < 0.001$) [6]. A statistically significant positive correlation was found between pre- and post-training lacquer thresholds and ventilation thresholds ($r = 0.96$ before training and $r = 0.86$ after training) [7]. Cao et al. proved through experiments that the ventilation threshold and
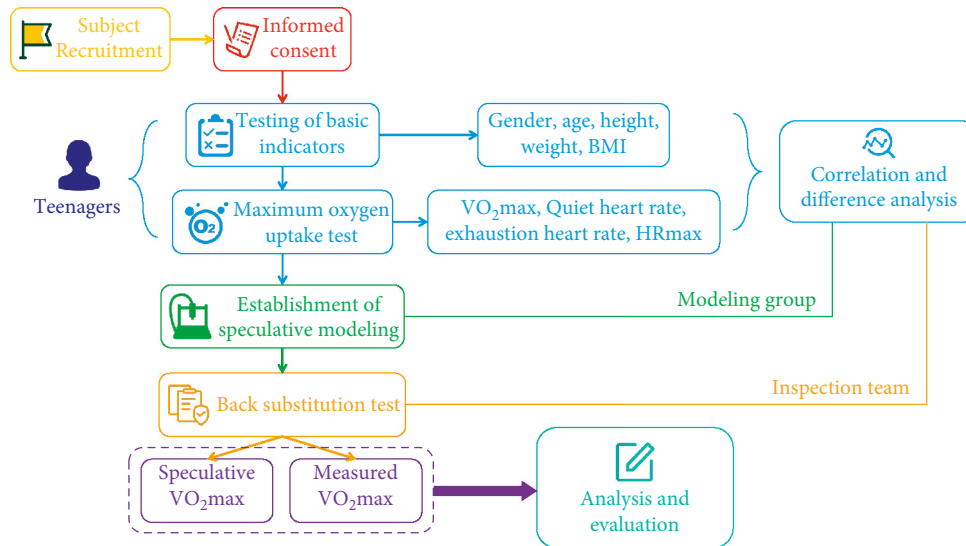
FIGURE 1: Construction process of identification regression equation.

lactate threshold decreased at the same time with the decrease of oxygen partial pressure, but the reduction range was different [8]. Wang et al. found that there was a high correlation between ventilation threshold and lactate anaerobic threshold, and the change of lactate caused the nonlinear change of ventilation threshold [9]. The heart rate of female cyclists at the sun lactate threshold was measured at 153 beats/min^{-1} and 137 beats/min^{-1} from the plateau airless ventilation threshold (2260 m). They proposed that it is more appropriate to take the heart rate at anaerobic ventilation threshold as the intensity index of aerobic training [10]. Li et al. found that, after 30 min exercise with the intensity of ventilation threshold, blood lactic acid can remain in a stable state [11]. Xing proved through experiments that anaerobic threshold intensity training can greatly improve swimming performance, while swimming performance higher than anaerobic threshold intensity training has a small increase [12]. Xing proposed that it is more appropriate to use the intensity equivalent to the speed of 3 mmol/L lactic acid or 85%~90% of the threshold speed of 4 mmol/L lactic acid as the intensity index of aerobic training for cyclists [13]. In the study, Zheng also used a way of exercise to explore and speculate the maximum oxygen uptake of such people and established a regression equation model [14]. Martinez et al. studied the method of measuring the cardiopulmonary capacity of junior middle school students aged 13–15 and calculated the regression equation model suitable for them through some morphological and physiological indexes [15]. Based on the current research, this study constructs the maximum oxygen uptake recognition regression equation of exercise training respiration and heart rate. Students were selected from high school and randomly assigned to modeling and experimental groups. In the first phase, more than 200 subjects were evaluated for body width, direct experiments to increase truck load were performed, and similar items were recorded. The indicators were compared and analyzed.

This study takes the specificity of heart rate recovery after exercise as the breakthrough point, and research studies a noninvasive and nondestructive evaluation method of aerobic capacity suitable for nonlaboratory conditions. Starting from the monitoring of aerobic capacity, this study improves the existing evaluation methods and has a high correlation with aerobic capacity (high correlation with VO_2 max) and can quantitatively study the detection method of aerobic capacity.

3. Methods

3.1. Research Object. Students were enrolled in high school. Participants' risk assessment questionnaires included participants' previous medical history, level of physical activity, and physical condition. Finally, 200 healthy young people aged 12–14 were selected, and 200 were selected by the design and experimental teams [16], of which 150 were in the group created and 50 in the board. Each class completes each test. Table 1 provides basic data of design groups and backup measurement groups. Interpretation statistics include age, height, weight, BMI, resting heart rate, resting heart rate, heart rate, maximum, and VO_2 max (gender code: male = 0 and female = 1).

3.2. Experimental Design. By contacting the teachers of a middle school for help and issuing the exercise and health questionnaire suitable for teenagers, the subjects of this experiment were recruited. The experiment involved 200 adolescents aged 12–14 years using a risk assessment questionnaire (PAR-Q) to understand a history of previous illnesses and levels of physical activity in order to identify diseases that are not suitable for exercise, such as congenital heart defects [17]. Prior to the test, a brief physical examination should be performed to ensure the safety of the subjects participating in the test.

Index	Modeling group	Inspection team
Age	13.3	13.33
Height	162.98	161.01
Weight	56.52	54.44
BMI	22.13	21.03
Quiet heart rate (beats/min)	97.58	96.11
Exhaustion heart rate (beats/min)	176.12	177.59
Maximum heart rate (beats/min)	170.24	173.45
Maximum load	122.41	125.99
Maximum oxygen uptake (L/min)	1.87	1.89

3.3. Main Indicators and Test Methods

3.3.1. Height and Weight Measurement.
Measurement method: barefoot, body upright, head upright, eyes looking straight ahead, trunk relaxed, and hands naturally placed on both sides of the body, fingers close together, heels close together [18].

Precautions: the measuring instrument shall be placed on the side close to the wall, and the scale on the instrument shall face the area with sufficient light. When reading the results, the measurer shall maintain the horizontal direction with the value. The horizontal plate shall not be too loose or too tight on the head, and it shall be appropriate [19].

Test tool are height and weight meter:

$$BMI\ measurement\ method: BMI = Weight\,(kg)/Height\,(m). \tag{1}$$

Using equation (2), main outcome measures are height, weight, and BMI index.

3.3.2. Measurement of Heart Rate.
Rs800cxpolar meter and heart rate monitor made in Finland are used to measure a patient's heart rate.

Test method: wet the conductive substrate slightly with water to ensure that the heartbeat zone is in close contact with the test participant. Participants were helped to find the lower part of the chest muscle by wearing a heart rate monitor. The heart rate can be adjusted for free. After completing the above steps, the polarity table and participants' heart rate will appear within two minutes. The heartbeat diagram always lights up when the participant's heart rate monitor appears on the image, and the heart rate key appears over time. Participants were asked to sit for another five minutes, after which the examiner recorded the heartbeat at rest [20].

3.3.3. Measurement of Blood Pressure.
The subjects' blood pressure was measured by Yutu brand xjl1d desktop sphygmomanometer and TZ-1 single use medical stethoscope produced by Shanghai medical equipment factory.

Test steps: before the experiment, relevant personnel shall zero the instrument and observe whether there are bubbles in the instrument [21]. The participants in the experiment wore a good heart rate belt and sat for five minutes. Then, the participants in the experiment sat on the power car, exposed the top of their arms, and kept level with their heart, and the orientation of the palms was upward. The participants tied the cuff to their arm and then placed the auditory head of TZ-1 in the direction of the brachial artery so that the two can be closely connected. Before using the stethoscope, the participants in the experiment should press the valve of the stethoscope tightly and then press the ball all the time, and then, slowly release the gas inside the inflatable ball. In the case of releasing gas, when the participants in the experiment heard the sound of "Dong Dong," the scale value on the protruding side of the mercury column was systolic blood pressure, and when the sound could not be heard, the scale value was diastolic blood pressure. After obtaining the relevant data, quickly release all the gas in the cuff [22].

3.3.4. Maximum Oxygen Uptake Test.
The German ergoline 05043156 vertical power bicycle and the German cortex exercise cardiopulmonary function test system metmax3b portable gas analyzer are adopted [23].

Determining maximum oxygen absorption: the researchers performed the high-pressure output of the MONARK821 electric bicycle, using the US-developed PHYSIO-DYNEMAX-1 electric motor to measure the maximum amount of oxygen, and increase the power of 30W without changing the speed to 60 rpm. Every 3.30 W per minute until the maximum oxygen inhalation standard P2 is reached, that is, (1) the air inhaled after exhalation less than 5% or 150 ml./min or 2 ml/(kg ∗ min), ② exhale > 1.10, heart rate > 180 beats/min, and ③ reduce oxygen intake with increased exertion.

Test steps: turn on the instrument and warm it for half an hour to test the instrument. Participants were placed on a heart-shaped measuring device, mounted on e-bikes, and stored in a quiet place until the instrument cranks were stable [24]. Test participants and test procedures are required. Select the appropriate scheme and then detect the surrounding air. Prepare test participants: wear a respirator; the sensors are set up, and then, help participants monitor changes in heart rate and airway data. You can experiment when you are ready. The test participants showed the value of oxygen absorbed when there was no energy. Participants completed the experiment [25].

3.4. Data Processing.
Data analysis was performed using Microsoft Excel 2003 and spss200 statistical analysis software; first, enter all data into a single document, subsequently test and access all data into SPSS software, and inspect all software files. Each means is $\pm a$ differential model ($x \pm SD$). A value is defined as $P < 0.05$, and a value is defined as $P < 0.01$. Gender, age, height, weight, BMI, resting heart rate, fatigue heart rate, maximum heart rate, and maximum load are independent variable, gender is indicated in virtual codes, and maximum oxygen consumption is a regression test variable and leads to regression of the equation.

4. Results and Analysis

4.1. Create an Optimal Regression Equation to Calculate VO2 Max

4.1.1. Selection of Independent Variables. The basic indexes of 150 subjects and the relevant indexes in the maximum oxygen uptake test experiment were correlated with the maximum oxygen uptake. The specific analysis can be seen from Table 2, so as to select the indexes with high correlation with the maximum oxygen uptake and statistical significance and then systematically analyze these data to clarify the correlation between them. The analysis was used as a basis for selecting the differences in freedom in terms of equality, and the most unaffected ones were gender, age, gender, pressure, weight, BMI, maximum heart rate, and maximum load, which were used as independent transducers in the regression analysis.

4.1.2. Establish Optimal Regression Equations. VO_2max should be selected based on measurements of sexual orientation, age, height, weight, BMI, heart rate, and maximum heart rate. Equilibrium regression included gender, weight, BMI, and 5 parameters. Maximum heart rate and maximum results of the retrospective test are shown in Table 3 and 4.

From Table 3 to 4, it can be inferred that the models for estimating the maximum oxygen uptake of adolescents are as follows.

Model 1. VO_2max $= -0.131 + 0.016 *$ maximum load.

Model 2. VO_2max $= -0.399 + 0.012 *$ maximum load $+ 0.013 *$ body weight.

Model 3. VO_2max $= -0.332 + 0.011 *$ maximum load $+ 0.011 *$ weight $+ 0.239 *$ sex.

Model 4. VO_2max $= -0.937 + 0.010 *$ Maximum load $+ 0.012 *$ Weight $+ 0.237 *$ Gender $+ 0.004 *$ Maximum heart rate.

Model 5. VO_2max $= -0.784 + 0.009 *$ Maximum load $+ 0.021 *$ Weight $+ 0.229 *$ Gender $+ 0.004 *$ Maximum heart rate $+ (-0.027) *$ BMI.

As seen in Table 3, when the maximum oxygen uptake is the difference and the maximum load, weight, sex, maximum heart rate, and BMI are the individual differences, the maximum coefficient of coefficient of V model is close to 0.9. The correlation is relatively close, and the degree of conformity of the simulation V is close to 0.8, which fully confirms that the degree of conformity of the set model V remains high. An independent variable can well explain a dependent variable, and the model is useful for hypotheses.

From the analysis of variance shown in Table 4, it can be inferred that the F value in model 5 is equal to 102.948, The significance probability is 0.000, which is much less than 0.001, indicating a clear linear relationship between maximum load, weight, sex, heart rate, and BMI and VO_2 max. Therefore, the estimation model is used to determine body

TABLE 2: Correlation coefficient between each index tested by subjects and maximum oxygen uptake.

Index	Maximum oxygen uptake (L/min)
Gender	0.487
Age (years)	0.212
Height (CM)	0.591
Weight (kg)	0.662
BMI (kg/m)	0.477
Quiet heart rate (beats/min)	0.021
Exhaustion heart rate (beats/min)	0.189
Maximum heart rate (beats/min)	0.239
Maximum load	0.745

TABLE 3: Summary of regression models.

Model	R	R^2	Adjust R^2	Standard error
1	0.745	0.586	0.556	0.258
2	0.892	0.678	0.638	0.234
3	0.78	0.765	0.715	0.251
4	0.887	0.717	0.756	0.290
5	0.848	0.718	0.747	0.250

TABLE 4: Anova.

Model		Sum of squares	Df	Mean square	F
1	Regression	15.772	1	15.773	
	Residual	11.983	148	0.080	194.805
	Total	27.757	149		
2	Regression	19.076	2	9.538	
	Residual	8.680	147	0.058	161.523
	Total	27.757	149		
3	Regression	20.987	3	6.995	
	Residual	6.76	146	0.045	150.866
	Total	27.757	149		
4	Regression	21.410	4	5.352	
	Residual	6.346	145	0.043	122.283
	Total	27.757	149		
5	Regression	21.68	5	4.337	
	Residual	6.067	144	0.041	102.947
	Total	27.757	149		

weight, height, sex, maximum heart rate, BMI according to different freedom, and VO2max according to the difference of reliability. The result of Durbin Watson test in Table 3 is 1.639, indicating that the independence of the error term in the regression model is relatively good.

4.2. Replacement Inspection.

After determining the equation for calculating the maximum oxygen consumption of adolescents, the accuracy of this equation was verified with 50 data from the experimental group. Specifically,

$$VO_2 \max = -0.784 + 0.009 * \text{Maximum load} \\ + 0.021 * \text{Weight} + 0.229 * \text{Gender} \qquad (2) \\ + 0.004 * \text{Maximum heart rate} + (-0.027) * \text{BMI}.$$
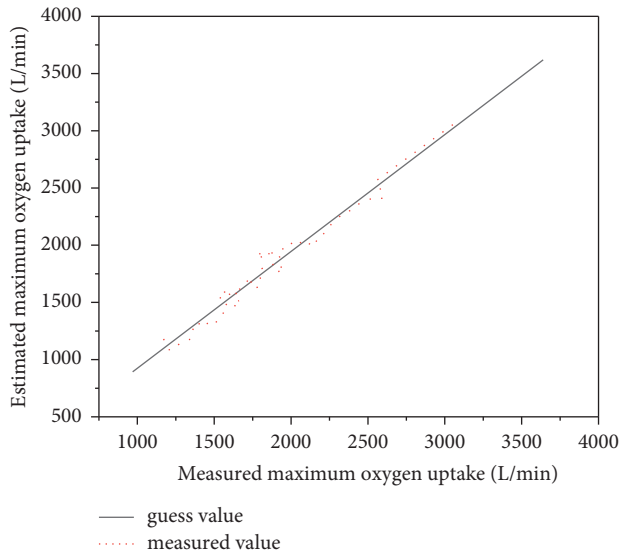
Figure 2: Scatter diagram between inferred maximum oxygen uptake and measured maximum oxygen uptake.

Table 5: Comparison of difference between measured value and inferred value.

Measured value of maximum oxygen uptake	Inferred value of equation	r
1.7721 ± 0.347	1.741 ± 0.394	0.979

Return all data to 50 participants in the experiment to return to equivalence, change in the experimental group, obtain a similar approximate value, and then compare with the actual data. The distribution of the comparison results is shown in Figure 2. You can see that here it is. Another benefit of the correlation coefficient is shown in Table 5. The conclusion is the correlation coefficient of the instrument, and the estimated VO_2 maxima of the return sample is 0.979, the significance level is 0.000, and the significance is less than 0.01. Interdependence is very important, and it shows that there is a clear relationship between the two. The predicted value is highly correlated with the measured value, and this formula shows that adolescents can effectively predict maximum oxygen consumption, as shown in Figure 2.

4.3. Error Inspection. The error ratio between the measured and predicted values of VO_2 max directly measured by the electric bicycle test was studied in a test group of 50 subjects. Conclusions: as shown in Figure 3, the error rate between the predicted value of the regression model and the maximum direct oxygen uptake measured directly using BMI as an independent variable using maximum load, weight, sex, and heart rate is within 10% for electric bicycle, 66% of the total sample of the reserve test, 49% of the total sample of the test group, which had 49 people, and only 1 person more than 15% of the total sample reserve test, which accounts for 2% of the total backup test sample.
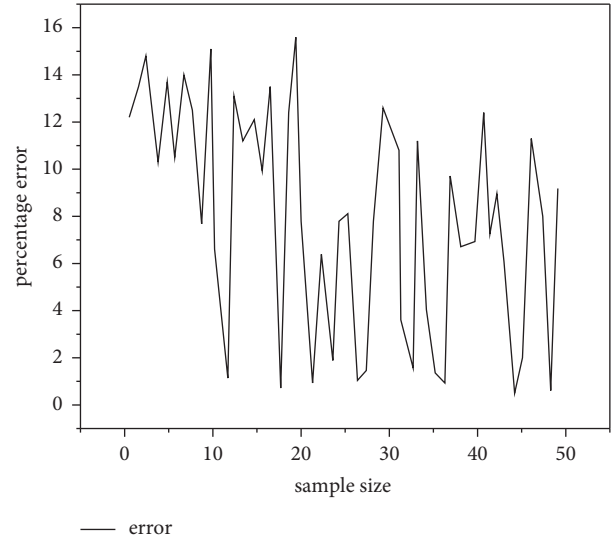

Figure 3: Error analysis of the inferred value and the measured value.

5. Conclusion

This study proposes a regression equation for determining the VO_2 max of exercise respiration and heart rate. Physiologically, VO_2 max is related to genetics, age, sex, physical activity, cardiovascular and respiratory function, muscle tone, function, and ability to absorb and use oxygen. The young are rapidly growing and have some morphological properties; height and weight have some influence on VO_2 max design. Based on this study, gender, age, height, weight, BMI, and heart rate were selected. Load according to the difference of independence; the results showed that the relationship between VO_2max and the maximum load is the largest, according to the weight, height, sex, BMI, and maximum heart rate. Finally, these constraints were chosen to make a discrepancy in the return.

In general, the advantage of this method is that VO_2max can be measured at the silence of the object and equipment required is small and easy to operate; once the equilibrium regression is developed, it needs to be tested, adjusted, and improved in practice. If possible, consider population, age, gender, and so on.

Data Availability

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

Conflicts of Interest

The authors declare no conflicts of interest.

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