Research and analysis of least square method identification of children's movement based on running and mountain climbing

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Abstract. In view of the difference of safe heart rate during exercise and fitness, this paper studies the suitable heart rate of children running and climbing in different physique, so as to provide scientific and effective exercise for children. In this paper, a least square method is proposed to identify children's movement based on running and mountain climbing. The least square method identification system of children's movement based on running and mountain climbing is established. Finally, through the MATLAB simulation analysis, the results show that the discrete identification method is suitable for children's safe heart rate and physical fitness, and the simulation results verify the feasibility and effectiveness of the least square identification method.

1. Introduction
With the decrease of physical activity, children's health problem will become an urgent problem in building a well-off society in an all-round way [1-3]. It doesn't matter. The fierce social competition makes most of the children spend their spare time in cram schools, specialty classes and homework. On the other hand, with the impact of informatization and networking, information tools such as computers and mobile phones have also entered many children's lives, occupying a lot of their living space. Moreover, with the acceleration of urbanization, the kind of hide and seek and jump greatly Rope and other traditional sports games have lost their space and place, and children are imprisoned in their own cages all day [4-18]. The comprehensive influence of these factors makes the physical activity of modern children decrease day by day, which makes children's health seriously threatened. The existing research shows that the main way to improve children's health is to exercise. For children of different physique in the growth and development period, scientific and reasonable exercise is an important means to promote their health [19-22].

The key of children's and adolescents' exercise is also the control of exercise intensity. For children of different physique types [23-26] in the same age group who are in vigorous growth and development, there are differences in their development degree. There are significant differences between their tissues, organs and systems, mature adults and peers of different physique, so they can't be designed for adults. The method of calculating relative intensity by limit heart rate was used to measure the suitable exercise intensity of children and adolescents with different physique [27-29]. Therefore, in order to
ensure the safety and effectiveness of children's sports, we must develop sports intensity suitable for children and adolescents with different physiques, so as to make scientific and reasonable sports programs for them, so as to improve their physique and promote their physical and mental health development. So as to formulate scientific and reasonable sports programs for them, thus improving their constitutions and promoting their physical and mental health development. Finally, through MATLAB simulation analysis [30-42], the results show that the discrete identification of suitable exercise heart rate and physical fitness for obese children is consistent with the actual results, and the simulation results verify the feasibility and effectiveness of the parameter adaptive model identification method.

In this paper, a least square method is proposed to identify children's movement based on running and climbing. The least square method identification system of children's movement based on running and mountain climbing is established. Finally, through the MATLAB simulation analysis, the results show that the discrete identification method is suitable for children's safe heart rate and physical fitness, and the simulation results verify the feasibility and effectiveness of the least square identification method.

2. Identification structure model

2.1. Research object
According to the data of physical fitness test in 2017 in Qingyang City, 220 fifth grade primary school students aged 10-11 in a primary school in Qingyang City (signed informed consent with their parents), including 120 boys and 100 girls. According to the height standard weight scale of primary school students, the students whose BMI is less than 18 are classified as thin group (54 people), the students whose BMI is more than 25 are classified as obese group (66 people), and the students whose BMI is between 18-25 are classified as normal group (100 people).

2.2. Research objects and methods
The accuspy portable blood lactate tester made in Germany, Jaeger laufergottest mobile running platform of blood lactate reagent strip and pe-4000 telemetry heart rate meter made in Finland were used for testing. Before the formal experiment in January 2018, two pre experiments were conducted. For the first time, the initial load was 7 km/h, and the load was added every two minutes, one km/h each time. However, due to the incomplete consideration, the whole process was in a passive state, so the ideal results were not obtained. In the second experiment, we set the starting load of normal group as 7 km/h, thin weak group and fat group as 6 km/h, and got ideal test results.

| Group          | Total number | Anaerobic threshold heart rate (b/min) | Anaerobic threshold heart rate (b/min) | Maximum heart rate (b/min) |
|----------------|--------------|---------------------------------------|---------------------------------------|---------------------------|
| Normal group(n=100) | 24           | 165±8                                 | 66±10                                 | 188±10.8                  |
| Obesity group(n=66) | 26           | 174±10                                | 73±11.0                               | 173±15.2                  |
| Weak group(n=26)     | 23           | 169±12                                | 85±10.0                               | 198±10.5                  |

Table 1 is a comparison of the data measured by the increasing load lactic acid threshold test between normal group and obesity group and between normal group and emaciated group between the same sex. From the table, it can be seen that there are obvious differences between normal group male and obesity group male as well as between normal group female and emaciated group female (P<0.05). the indexes
of anaerobic threshold heart rate, maximum heart rate and heart rate reserve have very obvious significant differences between different groups of the same sex (P<0.01).

To study the suitable heart rate of running and mountain climbing children with different physique, so as to provide scientific and effective exercise for children. In this paper, a least square method is proposed to identify children's movement based on running and climbing. The least square method identification system of children's movement based on running and mountain climbing is established.

3. least square method identification of children's movement

To study the suitable heart rate of running and mountain climbing children with different physique, so as to provide scientific and effective exercise for children. In this paper, a least square method is proposed to identify children's movement based on running and climbing.

Consider the following nonlinear discrete-time systems consisting of linear and nonlinear parts:

\[
\begin{cases}
x(m+1) = Ax(m) + bu(m) + \tilde{g}(x(m), u(m)) \\
y(m+1) = cx(m) + \tilde{h}(u(m))
\end{cases}
\]  

(1)

In the formula: \( u(m) \in R \) represents the control input of the system, \( y(m) \in R \) represents the system output, \( x(k) \in R^n \) represents the n-dimensional state vector, and \( \tilde{g}(), \tilde{h}() \) represents the smooth nonlinear function.

The expression can be expressed in the form of input and output, as follows:

\[
y(k+1) = \sum_{i=0}^{n-1} a_i \cdot y(k-i) + \sum_{j=0}^{d} b_j \cdot u(k-j) + g(\varphi(x)) = \varphi^T(x) \cdot \varphi + g(\varphi(k))
\]  

(2)

In the formula: the order \( n \) and delay \( d \) of the system are known numbers, the regression vector is represented by \( \varphi(k) = [y(k), \ldots, y(k-n+1), u(k), \ldots, u(k-n+1)]^T \), the linear parameter vector \( b \), and \( b > b_{\min} > 0 \), \( g(\cdot) \) assumes that the satisfied condition is a smooth nonlinear function composed of the higher order terms of \( \varphi(k) \).

Multi model building based on dynamic optimization model library

Establishment of linear local model:

\[
M_{ij} \cdot \hat{y}_{ij}(k+d) = \varphi^T(k) \cdot \hat{\theta}_{ij} \quad j = 1, 2, \ldots, c
\]  

(3)

In the formula: \( \hat{\theta}_{ij} \) is the identification parameter of the \( j \) th fixed model, and \( \hat{y}_{ij} \) is the output of the corresponding \( j \) th fixed model.

Free running adaptive model building:

\[
M_{eij} \cdot \hat{y}_{eij}(k+d) = \varphi^T(k) \cdot \hat{\theta}_{eij}(k) \quad j = 1, 2, \ldots, c
\]  

(4)

In the formula: \( \hat{\theta}_{eij} = [a_{c+1,0}, \ldots, a_{c+1,n-1}, b_{c+1,0}, \ldots, b_{c+1,n-1}]^T \) is the system model parameter, \( \hat{y}_{ej}(k+d) \) is the estimated output of the model.

The parameters are updated according to the following projection algorithm with dead zone according to \( \hat{\theta}_{eij}(k-1) \), as follows:
In the formula: \( e_{r+1}(k) \) represents the estimation error, \( y_r(k) \) is the system reference output. Using the formula (3)-(5) iteration, the model parameter estimate can be obtained.

**4. Experimental analysis and research**

The blood lactic acid-heart rate inflection point method is adopted to determine the target center rate of exercise prescription intensity control, a method of parameter prediction model identification based on weight loss exercise discrete system for obese children with different constitutions is given, and a parameter prediction model identification system based on weight loss exercise discrete system for obese children with different constitutions is established.

The least square method identification system of children's movement based on running and mountain climbing is established. Finally, through MATLAB simulation analysis.

**Fig 1.** Model system parameter identification laboratory.

Gymnastics Sports Population and other sports population, and uses MATLAB software to simulate and analyze the identification mode, as shown in Fig. 3, 4 and 5.

**Fig 2.** Anaerobic threshold heart rate identification.
Through the MATLAB simulation analysis, the results show that the discrete identification method is suitable for children's safe heart rate and physical fitness, and the simulation results verify the feasibility and effectiveness of the least square identification method.

![Identification Time vs. Identification Effect](image1)

**Fig 3.** Gymnastics class Sports population identification.

![Identification Effect vs. Parameter Identification](image2)

**Fig 4.** Quiet heart rate identification.

![Identification Effect vs. Parameter Identification](image3)

**Fig 5.** Running children of different physique.
5. Summary
In this paper, a least square method is proposed to identify children's movement based on running and climbing. The least square method identification system of children's movement based on running and mountain climbing is established. Finally, through MATLAB simulation analysis, the results show that the discrete identification method is suitable for children's safe heart rate and physical fitness, and the simulation results verify the feasibility and effectiveness of the least square identification method.

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Fig 6. Children's sports of different constitution in mountain climbing.

In Figure 2, 3, and 4, through MATLAB simulation analysis, the results show that the discrete identification method is suitable for children's safe heart rate and physical fitness, and the simulation results verify the feasibility and effectiveness of the least square identification method.
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