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The teaching of sports science of track and field-based on nonlinear mathematical equations

Fuyu Guan¹, Jie Cao¹, Jie Ren¹, Wenli Song^{1†}¹ Harbin Sports University, Harbin, 150008, China

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Abstract

This article uses the gray system theory of nonlinear mathematical equations to predict the best results of China's track and field events in the 2021 Olympic Games. And compare the above prediction information with the track and field performance of the 2021 Olympic Games. The article uses this to guide the teaching of Chinese track and field sports and analyze the relevant factors affecting Chinese track and field training.

Keywords: track and field sports, nonlinear mathematics, grey system theory, science teaching, 2021 Olympics, performance prediction, influencing factors

AMS 2010 codes: 93C10

1 Introduction

Track and field sports are the foundation of competitive sports and an important part of the Olympic Games. However, China has won only a handful of gold medals in track and field events in the recent Olympic Games [1]. In the 2021 Olympic Games, which Chinese track and field events can enter the top 8, top 3, or win gold? What are the factors affecting the development of Chinese track and field sports? These questions are the research purpose of this article.

2 Research objects and methods

2.1 Research object

The article takes the first Place in Chinese track and field from 1999 to 2021 and the first, third, and eighth Place in track and field events of the recent six Olympic Games (except for the male and female m and m relay

[†]Corresponding author.Email address: wenli88201655@163.com

events) research objects [2].

2.2 Research methods

2.2.1 Literature data method

In writing this article, I consulted many academic papers, newspapers and magazines, and other materials related to prediction, grey system theory, and track and field performance analysis [3].

2.2.2 Logical induction

We logically summarize the statistical results. It analyzes the current situation and development trend of the overall athletic level of men and women in Chinese track and field events from 1999 to 2021.

2.2.3 Mathematical Statistics

We summarize and organize the collected data and use Spss 16.0 and Matlab software for statistical analysis and comparison. Statistical diagnosis is to diagnose the whole process of solving problems by statistical inference methods, and impact analysis is a very important branch of statistical diagnosis [4]. At present, the research on the statistical diagnosis of linear regression models has been very in-depth. There are also some research results on the diagnosis methods of nonlinear models and generalized linear models. This paper systematically studies its statistical diagnosis and impact analysis methods by aiming at the widely used Poisson regression model. Consider the following model. Suppose y_i obeys the Poisson distribution, and its probability function is:

$$P(y_i, \theta_i) = \frac{1}{y_i!} \exp(y_i \theta_i - e^{\theta_i}) \quad (1)$$

Knownable

$$\begin{aligned} E(y_i) &= \mu_i = e^{\theta_i}, \quad \text{Var}(y_i) = e^{\theta_i} \\ \mu_i &= \exp(x_i^T \beta), \quad i = 1, 2, \dots, n \end{aligned} \quad (2)$$

(y_i, x_i^T) represents the data point of the group i , $x_i^T = (x_{i1}, x_{i2}, \dots, x_{ip}) \in R^p$ is a list of known non-random design points. $\beta = (\beta_1, \beta_2, \dots, \beta_p)^T$ is an unknown parameter. Equation (2) is called the Poisson regression model. If we assume $Y = (Y_1, Y_2, \dots, Y_n)^T$, $X = (X_1, X_2, \dots, X_n)^T$, $\mu = E(Y|X) = (\mu_1, \mu_2, \dots, \mu_n)^T$, the vector form of the Poisson regression model is: $\mu = \exp(X\beta)$. The log-likelihood function of Y concerning β is:

$$L(\beta) = \sum_{i=1}^n [y_i x_i^T \beta - \exp(x_i^T \beta) - \ln(y_i!)] \quad (3)$$

We mark the first and second derivatives of $L(\beta)$ concerning β as $\dot{L}(\beta)$ and $\ddot{L}(\beta)$ respectively, then

$$\dot{L}(\beta) = X^T Z \quad (4)$$

$$\ddot{L}(\beta) = -X^T V X \quad (5)$$

Where $Z = (z_1, z_2, \dots, z_n)^T$, $z_i = y_i - \exp(x_i^T \beta)$, $V = \text{diag}(v_1, v_2, \dots, v_n)$. We assume that the Poisson regression model (2) The maximum likelihood estimate of β is $\hat{\beta}$, then from (4) we know that $\hat{\beta}$ satisfies the following likelihood equation:

$$X^T z X = 0 \quad (6)$$

$\hat{\beta}$ can be solved by the Gauss-Newton iteration method. From (4) and (5), the Gauss-Newton iteration formula can be obtained as:

$$\beta^{i+1} = \beta^i + (X^T V(\beta^i) X)^{-1} X^T Z(\beta^i) \quad (7)$$

This formula can be formally expressed in the form of weighted least squares estimation:

$$\beta^{i+1} = (X^T V(\beta^i) X)^{-1} X^T V(\beta^i) W^i \quad W^i = X \beta^i + V^1(\beta^i) Z(\beta^i) \quad (8)$$

In the actual problem, we choose an appropriate initial value. The iteration of (7) can quickly converge. When the iteration converges

$$\beta = (X^T V X)^{-1} X^T V W \quad (9)$$

$$W = X\beta + V^1 Z \quad (10)$$

(8) and (9) In the two formulas, Z , V is calculated at β .

3 Research results and analysis

3.1 Prediction of China's track and field performance in the 2021 Olympic Games

The accuracy of prediction is the accuracy of prediction, which is used to describe the numerical performance of the degree of deviation between the predicted value and the actual value [5]. The accuracy of the gray prediction method is verified by comparing the results of the men's and women's first place in the track and field events of the 2021 Olympic Games with the predicted results. The average error rate of 4 of the 36 men's and women's track and field events in the 2021 Olympic Games is $>5\%$, while the average error rate of the other 32 events is between 1% and 5%. By further calculating, the average error rate is 1.50%, not $>2\%$ (Table 1). This shows that the gray prediction method has a high prediction accuracy for the entire sample. It can predict the first Place in Chinese track and field in 2021 and the first, third, and eighth Place in the Olympic track and field.

Table 1 2021 Chinese Men's and Women's No. 1 and Olympic Games No. 1, 3, 8 Predictions

Project	1st place		3rd place		Predicted ranking	
	Man	Woman	Man	Woman	Man	Woman
100 m	9.87	11.01	9.98	11.26		
200 m	19.84	22.27	20.03	21.28		
400 m	43.92	49.39	44.73	49.67		1
800 m	01:44.9	01:56.7	01:44.9	01:56.8	8	1
1500 m	03:32.6	03:55.6	03:32.8	04:08.8		
3000 m	08:13.7		08:14.4			
110 mH	12.91	12.52	13.13	12.59	1	
400 mH	44.95	52.74	48.3	53.3	8	8
5000 m	13:24.9		13:24.4			
10000 m	27:01.4		27:11.8			
20 km race walking	0.0433565		01:20.4		1	
50 km race walking	3:40:23		3:49:36		1	
Marathon	2:10:52	.2:24.36	2:12:09	2:26:24		1
Shot put	20.75	19.11	20.71	18.84	8	8
Discus	68.76	67.46	67.23	64.15	8	3
Javelin	89.22	68.53	87.96	63.93		
Hammer	80.402		78.61			
High jump	2.36	2.05	2.32	2.02	8	8
Long jump	8.49	6.95	8.32	6.9		
Pole vault	5.95		5.92			
Triple jump	17.84		17.5		8	
Decathlon	89/46	65/89	89/3	62/96		

Table 1 ...continued

Project	8th place		No. 1 in 2021		Predicted ranking	
	Man	Woman	Man	Woman	Man	Woman
100 m	10.05	11.1	10.22	11.49		
200 m	20.54	22.92	20.77	23.89		
400 m	45.72	51	47.1	49.01		1
800 m	01:49.6	1:58.43	01:46.8	01:52.6	8	1
1500 m	03:37.3	04:04.7	03:38.2	04:08.9		
3000 m	08:22.0		08:32.9			
110 mH	13.51	12.78	12.52	13.1	1	
400 mH	49.43	54.38	49.31	53.79	8	8
5000 m	13:29.2		13:55.0			
10000 m	27:46.4		29:03.1			
20 km race walking	1:25:47		1:15:54		1	
50 km race walking	3:51:15		3:26:39		1	
Marathon	2:15:00	02:28.1	2:15:73	02:17.9		1
Shot put	20.14	18.06	20.35	18.75	8	8
Discus	63.34	60.97	65.77	66.41	8	3
Javelin	85.76	62.52	80.78	58.83		
Hammer	77.13		69.72			
High jump	2.28	1.95	2.29	1.96	8	8
Long jump	8.27	6.74	7.98	6.51		
Pole vault	5.78		5.57			
Triple jump	17.04		17.14		8	
Decathlon	82/99	62/00	81/18	61/84		

According to the results of the gray prediction, at least 9 Chinese men's track and field events will enter the top 8 of the Olympic Games in 2021. Among them, 110 m hurdles, 20 km race walking, and 50 km race walking are expected to win medals in track and field. Projects like high jump and triple jump should continue to be developed as key projects. This can expand and maintain China's advantage at the world's track and field level [6]. And events like sprinting, long-distance running, throwing, and decathlon are still far from the world level. According to the gray prediction results, in 2021, at least seven Chinese women's track and field performances will enter the top 8 of the Olympic Games. Projects include marathon 400 m, 800 m, discus, shot put, high jump, and 400 m hurdles. Due to the late launch of the hammer throw, 20 km race walking, pole vault, triple jump, 5000 m, and 10000 m, it is not within the forecast. The marathon, 400 m, 800 m, and discus are among the items competing for medals. Shot put, high jump, and 400 hurdles are expected to be the top 8 items. The results of 100 m, 100 m hurdles, 200 m, 1500 m, javelin, long jump, and heptathlon are far from the world level [7]. Although the 20 km race walking, 5000 m, and 10000 m are not within the expected range, they can enter the top 8 according to the results of the previous Olympic Games. Even the hope of winning a medal is great.

3.2 Analysis of factors affecting the development of Chinese track and field sports

3.2.1 National system factors

The so-called nationwide system specifically refers to the guiding ideology, training management methods, and network system implemented in the field of competitive sports in China. The Chinese government attaches great importance to the strategic policy of the Olympic Games, while some coaches and athletes attach great importance to the strategic policy of the National Games [8]. From the rank-sum ratio of the individual best

results of men and women in Chinese track and field from 1999 to 2005, we can see the best results in 2004 and 2005, namely the Olympic year and the National Games year. The ratio is 2:7 for men and 1:3 for women. At present, the population of China participating in basic track and field training does not exceed 100,000, and the population participating in systematic training is <100,000. A total of 52 athletes participated in the 2004 Olympic Games. Therefore, the jobs of most coaches and athletes are maintained in the National Games. If the National Games system is not resolved, it will affect the results of the Olympic Games.

3.2.2 Economic input factors

Insufficient investment and difficulty in financing. Many necessary measures to improve the level of sports cannot be implemented in training competitions. Track and field events are more one-way (46 items), the team is large. Still, the level of exercise is relatively low, the social influence is low, and the attraction to enterprises is small, so it is more difficult to obtain social sponsorship. The insufficient investment makes track and field events, and although they are basic projects, they cannot be fully supported and developed [9]. Although we can make a difference in some projects, we cannot fully guarantee various teaching training methods in training and competitions. This is another reason why China's track and field performance is not high.

3.2.3 Technology level factors

Scientific theoretical knowledge and technical methods are widely used in various fields of sports. Various new materials provided by material science are widely used in sports equipment, clothing, construction, and other utensils. Electronic computers, televisions, video recordings, and other audio-visual equipment directly lead people to the process of physical education and sports training as a means of education and training [10]. Various scientific research tools such as scientific research experiment equipment and testing tools are adopted by sports science research. Physiology, biology, biomechanics, biochemistry, psychology, and other disciplines have more deeply involved in the research and guidance of track and field sports from more aspects. These technologies increasingly play a role in improving technology, improving physiological functions, performing psychological adjustment, preventing and curing trauma, and selecting athletes.

3.2.4 Coach factors

Coaches play a leading role in sports training, and they are directly related to the improvement of scientific training levels and sports levels. The textbook 'Sports Training Management' proposes that coaches have moral character, knowledge quality, ability quality, conceptual quality, temperament quality, and physical quality [11]. After the mid-1990s, the Track and Field Sports Management Center of the State Sports General Administration was established. We have changed the training management system from the 'centralized system' to a 'federal system.' This has achieved certain results, but it also exposed many problems. Some coaches' training plans, methods, and methods are kept secret, and even the phenomenon of mutual suspicion and unhealthy competition has arisen.

3.2.5 Athlete factors

The competitive ability of track and field athletes refers to the ability of athletes to perform the highest exceptional results or defeat opponents in track and field competitions. In major competitions, the normal performance level of outstanding foreign athletes reaches about 60%, while that of outstanding Chinese athletes is only about 25%. In the 28th Olympic Games, 27.1% of Chinese track and field athletes performed normally, and <7% showed the highest level. 19.23% of the athletes performed well [12]. The level of 53.84% of athletes dropped more. This is significantly lower than the comprehensive international ratio.

Sports life refers to the period from good performance to the best performance for athletes until retirement. Chinese men's best results are between 20 years old and 26 years old, and women are between 18 years old and 24 years old. Compared with the best athletes globally, the best competitive age is <5 years old [13]. The entire sports life span is 8–10 years short, and the best competitive age is between 25 years old and 29 years old. They stay in the competitive age group for 8–10 years. The best competitive age range of Chinese elite track and field athletes is between 20 years old and 24 years old, and the length of the competitive age group is relatively short.

Generally, 4–5 years, and the entire sports life span is relatively short.

3.2.6 Training system factors

The training management of grassroots sports schools deviates from the development stage of sports training. The selection of Chinese competitive sports consists of a three-level training system. The prefecture-level sports school manages the sports training process. The specific method is to link the various treatments of the coaches with the achievements of the athletes he trains. This ignores the physical and psychological development stages of children and adolescents. The evaluation system that only seeks results but not process leads to adultizing the training methods of children and adolescent athletes.

4 Suggestions

According to the results of gray prediction, focus on the development of sports that may enter the top 8 of the 2021 Olympic Games. Coaches and athletes should adjust their training plans from the National Games cycle to the Olympic cycle. We should adopt related policies to enable social organizations or individuals to increase their economic investment in track and field sports. Hire foreign coaches to coach and increase the training of excellent coaches. The coaches of the same project should communicate with each other. Improve the coaching level of the coaching team in terms of theory and practice. Pay attention to the training of mental training methods and sports psychology for athletes. Especially before the game, it is necessary to strengthen the training of mental preparation and sports psychology. Improve China's track and field training system. To extend the life span of Chinese track and field athletes, the best competitive age appears between 25 years old and 29 years old. This will ensure the sustained and stable development of China's track and field sports.

5 Conclusion

We predict that at least nine Chinese men's track and field events will enter the top 8 of the Olympic Games in China's track and field performance in the 2021 Olympic Games. Among them, 110 m hurdles, 20 km race walking, and 50km race walking are expected to win medals in track and field. At least seven Chinese women's track and field performances have entered the top 8 of the Olympic Games. The events include a marathon, 400 m, 800 m, discus, shot put, high jump, and 400 m hurdles. Factors affecting China's track and field sports development include the national system, economic investment, technological level, coaches, athletes, and training systems.

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