



Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Affect the sprint attainment of physical quality based on the theory of the gray model

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ABSTRACT

Have a connection with speed; track and field events in track and field sports, the most can reflect the speed of the project is the dash. This article through studies involved in the 100m sprint project dynamics, development trend of sprinters and impact performance of physical quality, establish the gray prediction GM (1, 1) model, get predict expressions of men's and women's 100m sprint. Using the Matlab software to analysis the factors that affect performance results in and mobilization, get motor skills are the main factors influencing the performance athletes. Conclusion shows that the athletes should pay special attention to in training of sports skill training, make the athletes according to reasonable skills take advantage in the game.

Keywords: Grey theory, Mathematical model, Short-distance running.

INTRODUCTION

Factors associated with the 100m run result has a lot of, such as stride length, stride length, speed, endurance, explosive force and muscle and joint flexibility and coordination, the athletes' psychological quality and technical level, look from the action structure of technology, seems to be simpler than other sports. But the error or defect in any one technology can be repeated dozens of times in training and competition, become the factors that affect performance, and every little improvement on technology, and then through strengthening, makes the athletes better achievements in the game. Therefore, to combine scientific training methods, effectively improve the effect of training, so as to master advanced, reasonable technology in the 100m run. Only in this way can give full play to the athletes in the game's potential, 100m good achievements.

In track and field projects, is inseparable from the speed, strength, stamina, agility and flexibility, and other physical quality. Due to the athletics has its special characteristics, determines the proportion of the special qualities. However, running, jumping, for three types of projects has the Special Forces, special endurance, but not necessarily can get excellent performance, but special speed is the key to the sports scores increased, it is the core of the gain performance. According to the principle of system theory of analytic hierarchy process (AHP) namely AHP method, the dominant class track and field physical speed XiangQun (represented by 100m) level of theory building and empirical research. Sprint special speed system theory to build (100m) from the subordinate relationship between the local and the overall system, the large system is 100m sprint speed, subsystem is special displacement and response speed. From the longitudinal hierarchy, special reaction speed is composed of reaction time and movement, the special displacement velocity is run by starting acceleration, acceleration, maximum velocity and the finish on the way of running speed. Because on the way to run maximum speed is the key to determine sprinters, therefore, the maximum speed as a big system, its system is made up of every single step movement speed, research on the way to run the largest speed single-step technology, can increase the speed of single step, and the stand or fall of single step speed directly affect the displacement speed, also can say hundreds of meters displacement velocity is composed of continuous single step speed. For hundreds of meters special research mainly from the way of running

the biggest displacement speed when a single step to study the technical structure, it includes the touchdown phase, vertical buffer stage, after the stage and empty stage.

This article through to in and outside of elite male sprinter run technical analysis on the way, can come to the conclusion that elite athletes common technical principles, technical solutions to seek suitable for China's athletes. Results predicted with the grey system theory, for this year's training, teaching and scientific research provides the basis of the concept.

MODEL ASSUMPTION

The top three athletes can represent the team overall activity levels. Only four factors influence the grade of the athlete as the movement skill, movement quality, physiology, the psychological quality. Athletes are only influenced by the factors as $mg, F_N, F_K, S, t, \theta$, and other factors are negligible.

SYMBOL DESCRIPTION

T0: used in the process of starting time

T1: center of gravity to have low legs straight time

T2: legs straight to the center of gravity highs used time

T3: gravity highs to just touch the ground force) (contact, but not to the time used

T4: just touches the ground force) (contact, but not used to the center of gravity low time

R: the correlation coefficient

O: the target layer

P: solution layer

A: judgment matrix

F_n: the force received in the movement

F_k: the air resistance in the movement

S: the difference of the center of gravity of the body when the legs bent and elongate

θ : the acute angle between the run-up ware and the ground

MODELING AND SOLVING

Mechanics model analysis of the 100m sprint

According to the physics knowledge to study, the the100 meters project is divided into five stages, namely the launching phase, centre of gravity is low to legs straight, legs straight to the centre of gravity is the highest stage, center of gravity highs to just touch the ground (contact, but not force) stage, just contact with the ground to the center of gravity low stage. After movement according to the four stages after the cycle is repeated. Divide the movement process, as shown in Figure 1 and figure 2:

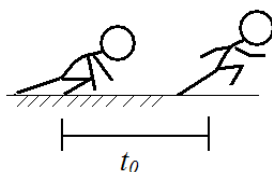


Figure 1. Starting phase

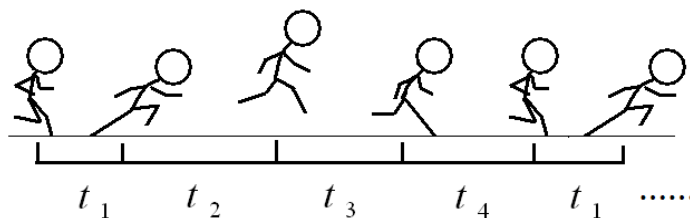


Figure 2. The process after the starting

Starting stage: in the vertical direction, according to theorem of momentum and theorem of kinetic energy:

$$(F_N \sin \theta - mg)S = \frac{1}{2}mv_0^2; (F_N \sin \theta - mg)t_0 = mv_0$$

Cycling stage: in the vertical direction, according to the theorem of kinetic energy:

$$(F_N - mg)S = \frac{1}{2}mv_{\text{vertical}_1}^2$$

According to theorem of momentum:

$$(F_N - mg)t_1 = mv_{\text{vertical}_1}; \quad mgt_2 = mv_{\text{vertical}_2}; \quad mgt_2 = mv_{\text{vertical}_3}; \quad (F_N - mg)S = \frac{1}{2}mv_{\text{vertical}_4}^2$$

$$(F_N - mg)t_1 = mv_{\text{vertical}_4}; \quad v_{\text{vertical}_1} = v_{\text{vertical}_4}; \quad v_{\text{vertical}_2} = v_{\text{vertical}_3}$$

In the horizontal direction, according to the theorem of momentum:

$$(\mu F_N - F_K)t_1 = mv_1, \quad F_K(t_2 + t_3) = mv_1 - mv_2; \quad (\mu F_N - F_K)(t_4 + t_1) = mv_3 - mv_4$$

$$F_K(t_2 + t_3) = mv_3 - mv_4; \quad (\mu F_N - F_K)(t_4 + t_1) = mv'_1 - mv_4; \quad F_K(t_2 + t_3) = mv'_1 - mv'_2$$

$$\text{In this cycle: } \dots (\mu F_N - F_K)(t_4 + t_1) = mv'^n_1 - mv'^n_2; \quad F_K(t_2 + t_3) = mv'^n_1 - mv'^n_2$$

In the starting stage, athlete's speed is influenced by the impact of mg, F_N, S, θ . In the moving stage, athlete's is influenced by the impact of mg, F_N, F_K, S, θ . The value of F_N is mainly affected by the influence of mg ; the value of S is mainly affected by the influence of the height; the value of F_K is mainly affected by the influence of athlete's speed; the value of t is mainly affected by the influence of s ; and athlete's speed is affected by the influence of t, F_N and μ . Generally, athlete's moving speed is mainly affected by mg, S, μ, θ .

Modeling of performance prediction

On the condition of exponential trend change, establish a model in the form of differential equation, i.e. gray system model. Conduct accumulated generating operation of the raw data $x^{(0)} = (x^{(0)}(1), x^{(0)}(2), \dots, x^{(0)}(n))$ according to the GM(1,N) model, and obtains that:

$$x^{(1)} = (x^{(1)}(1), x^{(1)}(2), \dots, x^{(1)}(n)) = (x^{(1)}(1), x^{(1)}(1) + x^{(0)}(2), \dots, x^{(1)}(n-1) + x^{(0)}(n))$$

The gray derivative of $x^{(1)}$ is defines as: $d(k) = x^{(0)}(k) = x^{(1)}(k) - x^{(1)}(k-1)$

Suppose $z^{(1)}$ is the mean value series of $x^{(1)}$, i.e.: $z^{(1)}(k) = 0.5x^{(1)}(k) + 0.5x^{(1)}(k-1), k = 2, 3, \dots, n$

Then $z^{(1)} = (z^{(1)}(2), z^{(1)}(3), \dots, z^{(1)}(n))$. As a result, the gray differential equation model GM(1, 1) is defined as:

$$x^{(0)}(k) + az^{(1)}k = b$$

Wherein, $x^{(0)}(k)$ is the gray differential coefficient, a is the development system, and $z^{(1)}(k)$ is the albino background value and b is the gray action.

Substitute time $k = 2, 3, \dots, n$ into the GM(1, 1) model, and obtain that:

$$x^{(0)}(2) + az^{(1)}(2) = b$$

$$x^{(0)}(3) + az^{(1)}(3) = b$$

⋮

$$x^{(0)}(n) + az^{(1)}(n) = b$$

Assume that: $Y_N = (x^{(0)}(2), x^{(0)}(3), \dots, x^{(0)}(n))^T, \mu = (a, b)^T$

$$\text{Assume that: } \mu = (a, b)^T, \text{记 } Y_{(1)} = (x^{(0)}(2), x^{(0)}(3), \dots, x^{(0)}(n))^T, \quad B = \begin{Bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{Bmatrix}$$

Based on the least squares method, it can obtain that: $\hat{\mu} = (B^T B)^{-1} B^T Y_1$

$$x^{(0)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a} \right) e^{-ak} + \frac{b}{a}$$

Thus the discrete solution expression of the gray differential equation is:

Solution of the model

(1) Successive Olympic Games 100m grades are shown in Table 1 below:

Table 1: Successive Olympic Games 100m achievements

Session times	1	2	3	4	5	6	7	8
Men	12.27	11.10	11.13	10.90	10.87	10.87	10.93	10.70
Women								
Session	9	10	11	12	13	14	15	16
Men	10.87	10.33	10.40	10.37	10.33	10.37	10.40	10.72
Women	12.27	12.10	11.70	12.10	11.80	11.77	11.73	11.90
Session	17	18	19	20	21	22	23	24
Men	10.23	10.13	9.97	10.24	10.09	10.34	10.37	9.89
Women	11.20	11.53	11.07	11.18	11.13	11.09	11.09	10.74
Session	25	26	27	28	29			
Men	10.01	9.88	9.97	9.86	9.83			
Women	10.95	10.83	11.02	10.95	10.91			

(2) Observe the figure and the Increasing exponential trend line, as shown in Figure 3:

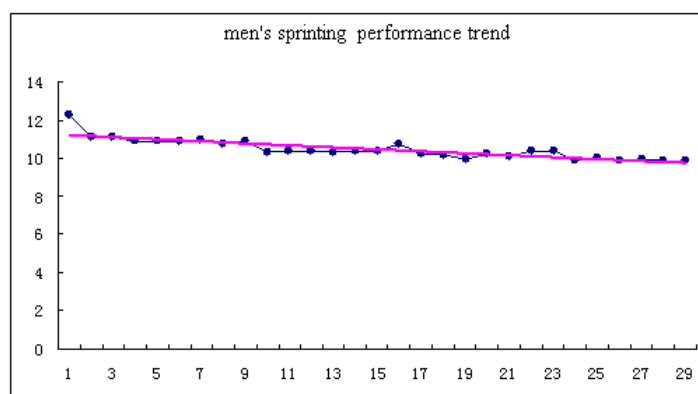


Figure 3. The graph of increasing exponential trend line

(3) Solving through matlab:

The calculation expression of the men's 100m sprint is:

$$x^{(0)}(k+1) = (12.27 - 2577.90698) e^{-0.0043k} + 2577.90698$$

The calculation expression of the women's 100m sprint is:

$$y^{(0)}(k+1) = (12.27 - 2017.06667) e^{-0.006k} + 2017.06667$$

(4) Graphical representation:

Male athletes of 100m running in the previous competition result change trend, as shown in Figure 4. Female athletes of 100m running in the previous competition result change trend, as shown in Figure 5.

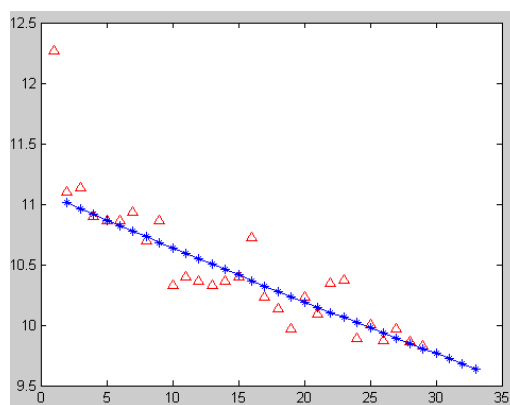


Figure 4. The performance trend for the 100m male sprinters in the previous games

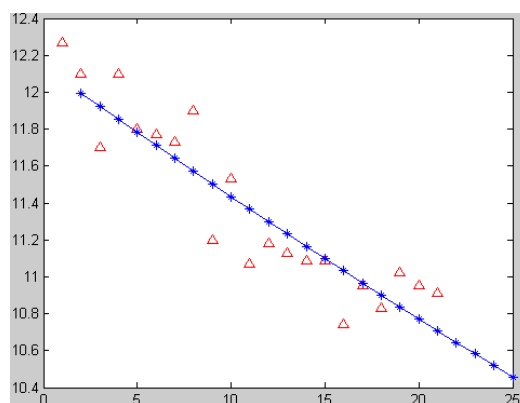


Figure 5. The performance trend for the 100m female sprinters in the previous games

Combining the above two images, can predict male athletes performance will be better and better, the time is more and more short, but the change is more and more small, tend to be 9.5; The female athlete is also tend to be 10.4.

4.4. Influence factors of athletes' performance

Analytic hierarchy process (AHP) is a qualitative, semi quantitative problem into a problem, an effective method is to analyze the multiple targets, multiple criteria of the complex large system of powerful tools, it is clear, the method is simple, practical area wide, systemic strong characteristic, it make people's hierarchical thinking process, through the layers are a variety of related factors for analysis, decision making, predict or control provide quantitative basis for the development of things.

(1) by gathering information, get the factors influencing performance athletes for: movement skill, movement quality, psychological quality, physiological function. The scale of the four factors according to the actual conditions is: 1,3,5,7.

(2) build hierarchy O - P: as shown in figure 6.

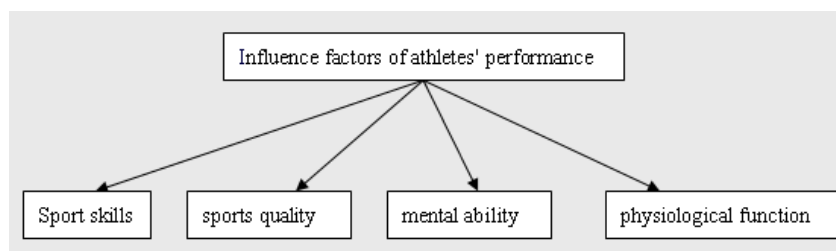


Figure 6. Constructing a hierarchical structure O-P

(3) Establish comparative matrix:

$$A = \begin{bmatrix} 1 & 3 & 5 & 7 \\ \frac{1}{3} & 1 & \frac{5}{3} & \frac{7}{3} \\ \frac{1}{5} & \frac{3}{5} & 1 & \frac{7}{5} \\ \frac{1}{7} & \frac{3}{7} & \frac{5}{7} & 1 \end{bmatrix}$$

$$CI = \frac{\lambda_{MAX} - n}{n-1} = 0$$

The smaller of CI, the higher the consistency of A is. CI = 0, it can be seen that matrix A is with high consistency.

$$RI = \frac{\lambda'_{MAX} - n}{n-1} = 0$$

$$CR = \frac{CI}{RI} < 0.1$$

∵ CR < 0.1 ∴ Matrix A has a relatively satisfactory consistency, i.e. the feature vector corresponding to λ_{max} is $\{-0.9239, -0.3080, -0.1848, -0.1320\}$, ∴ $\{0.4800, 0.2400, 0.1600, 0.1200\}$ is the calculated weight. The incidence of sport skills, sports quality, mental ability and the physiological function on athletes' performance are respectively: 0.48, 0.24, 0.16, and 0.12.

CONCLUSION

We get from the above research: reasonable arrangement of all kinds of training content, comprehensively improve the quality, athletes in the process of the specific training not only through the special strength training to form and consolidate the right technology, but also according to the actual athletes, use all kinds of training means, so that the cerebral cortex can stimulate in various conditions, constantly improve the excitement, improve the strength of the neural processes and flexibility, prevent the formation of "hitting the wall". In the weeks training plan, want to have a combined technology of special strength training, 3 ~ 4 times of auxiliary training to develop the athlete's absolute speed, speed endurance and aerobic endurance, make the athletes after high intensity anaerobic training the body to adjust, recovery, better for the second day of training.

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