BioTechnology

An Indian Journal

FULL PAPER

110m hurdle performance and physical quality indicator grey relational analysis based on matlab simulation

Yan Zhang[1]*, YinMin Liu[2]

[1]Institute of Physical Education, The northeast normal university, Changchun, 130024, Jilin, (CHINA)
[2]Sports actuarial-oriented, Changchun university of technology, Changchun, 130022, Jilin, (CHINA)

ABSTRACT

Hurdle has already developed for more than one century until now; it has great improvements both in rules and hurdle structures. Chinese sports undertakings development have also made greater progress since opening and reform, from which in athletics competitions, now lots of scholars are striving for exploring so as to improve hurdle running performance. Apply each kind of science and technology ways, analyze and research hurdle running performance influence factors, and explore theoretical basis for hurdle running training. The paper does research on 110m hurdlers performances correlation factors. By establishing athletes sport ability indicators and performances relationships, analyze their correlation coefficient and solve correlation degree. And according to that, it solves weight values and establishes performance and factors equations. By comparing Chinese and foreign different excellent athletes' parameters, through analyzing and researching, it gets each factor importance in performance that is weight, by mathematical model establishing, it further analyzes performance influence factors and makes relative training suggestions.   © 2014 Trade Science Inc. - INDIA

KEYWORDS

110m hurdle;
Grey correlation degree;
Matlab software;
Sport performance;
Influence factor.

INTRODUCTION

Chinese sports undertakings development have also made greater progress since opening and reform, successfully host Olympic Games in 2008 greatly propel to Chinese sports undertakings rapidly development. And China now is under realizing conversion from a major sports country to a world sports power. Hurdle running belongs to one of athletics events, is a kind of the oldest sports events, 21st century new era has started a new chapter on Chinese hurdle, Liu Xiang outstanding performance let people excited. In Greek Athens hosted 28th Olympic Games men's 110m hurdle final, he won the champion with 12.91s, the performance was tied to Colin Jackson created world record of 12.91s in 1993.

To further guide hurdle training, and achieve breakthrough in performance, in the research of hurdle theory, Chinese scholars obtained some results through lots of researches. Among them, Deng Wan-Jin etc. by analyzing performance and relative indicators relations, he got that the key to performance was up to athletes hurdle and running coordination, which provided training direction for further improving hurdle performance. Zhou

FULL PAPER

Jian-Lei etc. in the article of "Research on domestic different levels 110m hurdlers rhythm differences between hurdles", applied mathematical statistics, carried out analysis and research on data, they thought flat technical direction is modern hurdle running technical development, and "speed loss" existed between athletes hurdle running and their flat, the key to improve hurdlers 110m hurdle performance was reducing "speed loss". Wang Hai-Bo by discussing sport speed special quality factors relations, he respectively made research on special strength training, special technical training, special quality, and proposed that improve flat was the direction of hurdle training. Wang Yong took foreign excellent hurdlers technical features as references, made comparative research on Liu Xiang 110m hurdle time features; he thought that in time allocation, development towards balance was effective method to improve sport performance. Wang Wei by comparing Chinese and foreign excellent athletes hurdle whole journey time distributions and data analysis, he researched hurdle running time features, and found out Chinese athletes and foreign athletes differences as well as make up shortcomings, which provided path for further improving hurdle running performance.

This paper will further analyze hurdle running performance and athletic ability indicators relations. On the basis of previous research, it defines researched athletic ability indicators and goes deeply into theoretical analysis. On the basis of traditional numerical analysis, regression equation and other mathematics, apply grey mathematical theory exploring indicators and performance correlations, define different indicators affect hurdle running performance in which degree, define each indicator and performance correlation degree, and verify model feasibility. Influence factors contributions sizes decide athletes training direction and training indicators emphasis problems, which can provide theoretical basis for further improving athlete performance.

110M HURDLE SPORT PERFORMANCE AND INFLUENCE FACTORS ANALYSIS

In our life lots of practical problems' inner relations, structures, parameters as well as features, we cannot fully understand them. Only establish their relations by some unclear connection. We call system with partial known information and partial unknown information as grey system. The paper starts from grey system original feature grey, researches on information greatly lacking of clear correlations system. Grey system can better fit and find out things grey relations, and accordingly solve and handle with practical problems. Especially for practical problems that things relations cannot be exactly known.

Research objects

This paper takes world excellent 110m hurdlers information and sport technical features as objects, respectively takes Oliver, Payne, Noga, Robles, Thomas, Liu Xiang, Arnold, Doucoure and others as samples to do research, staff samples individual information is as following TABLE 1.

TABLE 1 : Athletes information table

Athlete	Nationality	Height(m)	Best performance(s)
Payne	America	1.83	13.08
Oliver	America	1.91	13.06
Robles	Cuba	1.92	12.87
Noga	Poland	1.89	13.16
Liu Xiang	China	1.88	12.88
Thomas	Jamaica	1.85	13.12
Doucoure	France	1.83	12.97
Arnold	America	1.86	12.90

Research methods

Correlation degree analysis method is put forward by grey system theory. Different from regression equation, it has unique advantages. Grey correlation degree, according to factors development states similarity or difference degree to judge factors correlation degree, it reveals factors dynamical correlation features and degrees. Correlation degree geometric significance is similarity degree after factor converted into function images. Its calculated amounts are less and not prone to appear correlation degree quantization result and qualitative analysis inconsistent status.

In hurdle running, there is more movement indicators affect performance. We always need to analyze each indicator to define in these indicators which are major ones for performance, which are the secondary ones, which needs to be developed, which needs to be restrained, which are the potential ones, and which are

the obvious ones. To improve 110m hurdle running performance, indicators importance is problem with our great concerns. In fact, how do factors correlations like and how to quantify correlation degree and other problems are key and starting points of system analysis. Correlation analysis, which is also system's each factor relative statistical data geometric relations comparison. Hurdle running in the whole process, it is constantly developing, as a developing and changing system, correlation analysis carries out quantization comparative analysis of instant speed waste rate, flat speed use rate, and hurdle running coordinate ability dynamical process development state, and analyzes their correlations with performance, it further researches on world excellent 110m hurdlers technical features, and provides theoretical basis.

Correlation solution method is as following:

(1)At first carry out data transformation

Because collected original data with different dimensions that have no comparability, to ensure modeling result accuracy, it should proceed with data transformation. Method is as following:

Define 1 Ordered sequence $x = (x(1), x(2), \cdots x(n))$

And then call map

$f : x \to y$

$f(x(k)) = y(k), k = 1,2, \cdots n$

It is sequence x to sequence y data transformation. Its data transformation has: initialization transformation, mean transformation, percentage transformation, multiple transformation, normalization transformation, maximum range transformation, interval values transformation and so on. Here adopts transformation:

$f(x(k)) = \dfrac{x(k)}{x(1)} = y(k), k = 1,2, \cdots n \boxplus x(1) \neq 0$

That is f initialization transformation.

(2) Correlation coefficient

Select reference sequence. In the paper, reference sequence is athlete hurdle performance x_0. Other sequences are comparison sequences.

Reference sequence

$x_0 = \{x_0(k) | k = 1,2, \cdots n\} = (x_0(1), x_0(2) \cdots x_0(n))$

Among them, k represents athlete, assume it has m pieces of comparison sequence:

$x_i = \{x_i(k) | k = 1,2, \cdots n\} = (x_i(1), x_i(2) \cdots x_i(n)), i = 1,2, \cdots m$

Then it calls

$$\xi_i(k) = \frac{\min\limits_s \min\limits_t |x_0(t) - x_s(t)| + \rho \max\limits_s \max\limits_t |x_0(t) - x_s(t)|}{|x_0(k) - x_i(k)| + \rho \max\limits_s \max\limits_t |x_0(t) - x_s(t)|} \quad (1)$$

It is comparison sequence x_i to reference sequence hurdle performance x_0 at t moment correlation coefficient, from which $\rho \in [0,1]$ is resolution coefficient. In above formula, $\min\limits_s \min\limits_t |x_0(t) - x_s(t)|$, $\max\limits_s \max\limits_t |x_0(t) - x_s(t)|$ are respectively two-level minimum difference and two-level maximum difference.

Generally speaking, the bigger resolution ratio is, then the bigger resolution coefficient ρ would be, the smaller resolution ratio is, and then the smaller ρ would be, here the calculation takes $\rho = 0.5$.

(3) Correlation degree

Correlation coefficient is a kind of indicator describing reference sequence and comparison sequence at some time correlation degree, due to each point has a correlation coefficient, it is not convenient to compare, so give correlation degree definition:

$$r_i = \frac{1}{n} \sum_{k=1}^{n} \xi_i(k) \quad (2)$$

It is sequence x_i to reference sequence x_0 correlation degree. Correlation degree is concentrating each time correlation coefficient into an average value, which is also do collective handling with excess scattering information. Utilize correlation degree the concept, it can analyze and research hurdle performance influence factors.

The solution, input initialized TABLE 1 data into formula(1),(2), it can get each sequence correlation degree by calculating, similarly input TABLE 2 data to calculate.

Calculated MATLAB program is as following:

```
clc,clear
load x.txt
for i=1:15
```

FULL PAPER

TABLE 2 : Correlation coefficient and correlation degree

Athlete	Payne	Oliver	Robles	Noga	Liu Xiang	Thomas	Doucoure	Arnold	Correlation degree
Correlation coefficient	0.566	0.589	0.612	0.552	0.668	0.576	0.622	0.608	0.599

```
x(i,:)=x(i,:)/x(i,1);
end
for i=16:17
x(i,:)=x(i,1)./x(i,:);
end
data=x;
n=size(data,1);
ck=data(1,:);m1=size(ck,1);
bj=data(2:n,:);m2=size(bj,1);
for i=1:m1
for j=1:m2
t(j,:)=bj(j,:)-ck(i,:);
end
jc1=min(min(abs(t')));jc2=max(max(abs(t')));
rho=0.5;
ksi=(jc1+rho*jc2)./(abs(t)+rho*jc2);
rt=sum(ksi')/size(ksi,2);
r(i,:)=rt;
end
r
[rs,rind]=sort(r,'descend')
```

Indicators and performance correlation degree

Speed loss and performance correlation degree when hurdling

Analyze world excellent athletes speed loss and hurdle running performance correlation coefficients and correlation degree, athletes speed waste rate statistics use matrix to express, then it has

$$A_1 = \begin{pmatrix} 0.38 & 0.28 & 0.26 & 0.48 & 0.50 & 0.32 & 0.28 & 0.26 & 0.20 & 0.20 \\ 0.28 & 0.32 & 0.16 & 0.18 & 0.36 & 0.22 & 0.32 & 0.32 & 0.28 & 0.19 \\ 0.26 & 0.20 & 0.28 & 0.24 & 0.32 & 0.40 & 0.30 & 0.25 & 0.20 & 0.32 \\ 0.18 & 0.33 & 0.26 & 0.30 & 0.26 & 0.32 & 0.20 & 0.20 & 0.18 & 0.16 \\ 0.34 & 0.20 & 0.18 & 0.15 & 0.16 & 0.20 & 0.24 & 0.26 & 0.24 & 0.20 \\ 0.26 & 0.34 & 0.24 & 0.40 & 0.22 & 0.32 & 0.23 & 0.26 & 0.24 & 0.20 \\ 0.28 & 0.25 & 0.34 & 0.26 & 0.28 & 0.28 & 0.22 & 0.20 & 0.16 & 0.26 \\ 0.30 & 0.34 & 0.11 & 0.22 & 0.22 & 0.14 & 0.26 & 0.25 & 0.18 & 0.18 \end{pmatrix}$$

In matrix, column represent the first hurdle, the second hurdle till the tenth hurdle speed loss that is grey correlation degree solution's comparison sequence; in matrix, row represents athlete Payne, Oliver, Robles, Noga, Liu Xiang, Thomas, Doucoure, Arnold technical parameters. At this time, selected reference sequence is hurdle running performance. Use matrix to express, then:

$$B_1 = \begin{pmatrix} 1308 & 1306 & 1287 & 1316 & 1288 & 1312 & 1297 & 1290 \end{pmatrix}^T$$

According to above correlation degree algorithm, apply program calculating, it can get every hurdle speed loss and hurdle running performance correlation degree, after sorting, use matrix to express, it has:

$$R_1 = \begin{pmatrix} 0.29 & 0.28 & 0.23 & 0.28 & 0.29 & 0.28 & 0.26 & 0.24 & 0.20 & 0.22 \end{pmatrix}$$

Hurdle waste rate and performance correlation degree calculation indicates that correlation degree in the first, second, fourth, fifth and sixth hurdle is obvious larger than other hurdles'. It shows that first, second, fourth, fifth and sixth hurdle speed waste rate has larger influences on performance; in speed loss, reduce these hurdles speed loss can more helpful for planning and estimation improving. By practical training analyzing, it is known that the first, second hurdle is starting phase, starting speed and status are crucial to performance; the fourth, fifth, and sixth hurdle due to belongs to middle phases, which should ensure connections with previous phase and also adjusts rhythm for later phase hurdling that serves as a link between past and future, better speed control is important guarantee of former and later connections.

Flat speed use rate and performance correlation degree

110m flat speed is direct related to 110m hurdle speed that is positively correlated. Flat speed use rate in hurdle is the important indicator for flat converting into hurdle running. In statistical matrix, column represents athletes' hurdle speed, flat speed and use rate, from which the last one is regarded as reference sequence.

$$A_2 = \begin{pmatrix} 13.08 & 10.62 & 0.81 \\ 13.06 & 10.52 & 0.81 \\ 12.87 & 10.52 & 0.81 \\ 13.16 & 10.74 & 0.82 \\ 12.88 & 10.90 & 0.85 \\ 13.12 & 10.70 & 0.82 \\ 12.97 & 10.76 & 0.83 \\ 12.90 & 10.50 & 0.81 \end{pmatrix}$$

Reference sequence is hurdle running performance, use matrix to express and then:

$$B_1 = (13.08 \quad 13.06 \quad 12.87 \quad 13.16 \quad 12.88 \quad 13.12 \quad 12.97 \quad 12.90)^T$$

According to grey correlation coefficients calculation, it gets correlation coefficient and correlation degree TABLE 2.

Correlation coefficient calculation result shows that Robles, Liu Xiang and Doucoure use rate is higher, especially Liu Xiang's use rate is the highest, which proves Liu Xiang has stronger stability in hurdle, he hasn't excessively wasted speed due to hurdling, therefore his performance is relative outstanding. Flat speed use rate correlation degree is 0.599 which indicates as higher that speed use rate has larger contribution rate in performance. Increase hurdling ability, reduce speed loss is the important path to improve 110m hurdle performance.

Hurdle's coordinate ability and performance correlation analysis

Hurdle's coordinate ability is a coordinate ability that reflects flat motion and hurdling motion combination, better coordination can let athletes play flat speed to greater degree and get higher hurdle running performance. Hurdle running coordinate ability indicators has connections with before hurdling speed and during hurdling speed gap as well as flat speed use rate.

Defining hurdle running coordinate ability quantization value computational formula: $Y = ay_1 + by_2$

In formula, Y represents athletes' hurdle running coordinate ability, y_1 represents before hurdling average speed and after hurdling average speed ratio, y_2 represents 110m hurdle performance and 110m flat performance ratio. a、b respectively expresses two indicators weights, respectively takes. $a = 0.6, b = 0.4$. By above definition calculation, the smaller the value is, the better coordinate ability is. Athletes' flat performance, hurdle running performance, before hurdling average speed, during hurdling average speed, as well as y_1, y_2, Y value as following TABLE 3.

Reference sequence is performance, use matrix to express, then:

$$B_1 = (13.08 \quad 13.06 \quad 12.87 \quad 13.16 \quad 12.88 \quad 13.12 \quad 12.97 \quad 12.90)^T$$

Comparison sequence is hurdle running coordinate ability, use matrix to express:

$$A_3 = (1.14 \quad 1.15 \quad 1.15 \quad 1.14 \quad 1.11 \quad 1.15 \quad 1.13 \quad 1.15)$$

According to grey correlation coefficients calculation, it gets correlation coefficient and correlation degree TABLE 4.

Result analysis, by TABLE 3, TABLE 4, it can get Liu Xiang hurdle running coordinate ability is stronger; correlation coefficient is higher, which reflects better performance. It shows hurdle running coordinate ability sizes play crucial roles to performance.

TABLE 3 : Hurdle running coordinate ability calculation table

Athlete	Performance		Speed		Indicator		Hurdle running coordinate ability
	Flat	Hurdle running	Before hurdling	Hurdling	y_1	y_2	
Payne	13.08	10.62	8.28	8.16	1.23	1.01	1.14
Oliver	13.06	10.52	8.40	8.24	1.24	1.02	1.15
Robles	12.87	10.50	8.34	8.12	1.23	1.03	1.15
Noga	13.16	10.74	8.16	8.00	1.23	1.02	1.14
Liu Xiang	12.88	10.90	8.26	8.18	1.18	1.01	1.11
Thomas	13.12	10.70	8.30	8.10	1.23	1.02	1.15
Doucoure	12.97	10.76	8.42	8.22	1.21	1.02	1.13
Arnold	12.90	10.50	8.48	8.28	1.23	1.02	1.15

TABLE 4 : Correlation coefficient and correlation degree

Athlete	Payne	Oliver	Robles	Noga	Liu Xiang	Thomas	Doucoure	Arnold	Correlation degree
Correlation coefficient	0.42	0.41	0.40	0.42	0.45	0.41	0.42	0.40	0.416

FULL PAPER

CONCLUSIONS

In 110m hurdle, starting phase and middle transition phase are most important. It needs to strengthen athletes' explosive power to improve starting phase hurdling speed, meanwhile it should reasonable allocate speed relations; ensure middle phase speed smooth transition which develops toward balance speed. Flat speed use rate and hurdle running coordinate ability is the important path to improve hurdle performance, increase athletes' running, hurdling coordinate training, and pursuit improving speed use rate. Especially hurdle running coordinate ability exercise, coordinate ability increasing, and then athletes hurdle running and hurdling perfect combined which can improve 110m hurdle performance to great degree.

REFERENCES

[1] Song Yue-Xian, Peng Zhi-Yu; P.E. Dept. of Hunan University, Hunan, Changsha, China. P.E. Group of the Middle School Attaches to Hunan Normal University, Hunan, Changsha, China. The Kinematics Character Analysis of 110m Hurdles Steps and Hurdles Period of Chen Yan-hao[J]. Sichuan Sports Science, **3**, 33-34 **(2001)**.

[2] Li Jian-Chen, Fu Da-Peng; Kinematic Analysis on Run-stepping and Step-running Technique of 110 m Male Hurdler[J]. China Sport Science and Technology, **36(5)**, **(2000)**.

[3] Xu Xi-Gen, Zhang Li-Hua,n Liu Qi, Yang Zhi-Hua; Physical Education College of Jiangxi Normal Unive-rsity,Nanchang, China..Technical Analysis on Man's 110 m Hurdling of LIU Xiang[J]. China Sport Science and Technology, **40(4)**, 1-2 **(2004)**.

[4] Tan Zhi-Ping; Research on Time-space Characteristics of Rhythm and Speed Changes of Domestic and Foreign Elite Athletes of Hurdle Event[J]. Journal of Beijing Sport University, **28(5)**, 700-702 **(2005)**.

[5] Wang Jinghua, Li Ning; Analysis of the Technique of Hurdle Step and Run between Hurdles[J]. Journal of Wuhan Institute of Physical Education, **34(1)**, 92-94 **(2000)**.

[6] Li Bao-An; Technical feature analysis of attack into the hurdle stage of the 5th hurdle of 110 metres hurdles of LIU Xinag[J]. Shandong Sports Science & Technology, **27(3)**, 42-44 **(2005)**.

[7] Xu Yi-Cheng; Analysis on 110m Hurdler Liu Xiang's Technique[J]. Sports Science Research, **25(4)**, 31-33 **(2004)**.

[8] Peng Zhi-Yu et al; The Analysis Of Hurdling Skill On Chinese Top 110m Hurdler[J]. Fujian Sports Science and Technology, **24(2)**, 21-23 **(2005)**.

[9] Tang Lin, Song Yuexian, Yang Zuo, Duan Honghua; Kinematics Analysis of Hurdling Skill On Chinese Top 110m Hurdler[J]. Journal of Hubei Sports Science, **26(2)**, 195-197 **(2007)**.

[10] Song Yue-Xian, Tang Lin; Technical analysis of Liu Xiangps level ing world record of 12. 91s in 110m hurdle[J]. Journal of Wuhan Institute of Physical Education, **41(6)**, 66-68 **(2007)**.