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110m Hurdles phased performance significance research based on SPSS regression analysis and GRA model

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ABSTRACT

In 21st century, Chinese men 110m hurdle suddenly raised analysis and research on hurdle performance and techniques have already become a hot topic. Carry out researching on 4 factors significance that affects hurdle performance, utilizes multiple linear regression, analyzes Liu Xiang 110m hurdle total performance significance in stages from start to first hurdle, hurdle step soaring, three-pace running, the last exertion, then applies SPSS software in implementing unknown parameters estimation and significance testing. To define 4 factors correlations with total performance, establishes grey relational degree model, gets that techniques in last exertion, from start to first hurdle are Liu Xiang strong points, and techniques in three-pace run, hurdle step soaring are his weak points.

Key words: 110m hurdler, Regression analysis, Grey Relational Analysis, Statistics

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INTRODUCTION

100m hurdle running appeared first in Britain in 1830. Since 1864, it started 109.7m hurdle running, while Frenchmen added 28cm let it into 110m hurdle running in 1888. There were already 100m hurdle running event in Olympic Games in 1896, however, due to hurdle techniques did not perfect at that time, the result only was 17.6s that not ideal. In the second Olympic Games it started 110m hurdle running, the event has been introduced into China before and after 1900, and it was listed into national game formal competition event in 1910. In Aug. 28th 2004, Liu Xiang wrote down Chinese name in Europe and American monopolistic Olympic Game Championship lists with the stunning time of 12.91s, which changed Chinese athletics 110m hurdle history even the whole sports history that denied the final conclusion of" Yellow race inherent disadvantages in sprint"[1-3].

For hurdle research, Shandong normal college's Huang Jing-Hua in 2007 published "Our country women 100m hurdle current situation analysis and counter measurement research", mainly researched on women hurdle development history as well as performance improving process [2-3]. In October, 2012 Hong Xiang-Shun, Xu Wan-Fei published "Our country 110m hurdle history review as well as development research summary" in sports world, mainly carrying out simple statement on our country current 110m hurdle history, put forward our country 110m hurdle development root causes [3-6]. Reviewing China 110m hurdle history and development, 110m hurdle as a top priority country sport event is beyond all doubt, therefore, took it as cut points, looked up China 110m hurdle event advantages and carry them forward, meanwhile comparing with foreign similar event development advantages, learnt from each other and propelled to our country 110m hurdle event move further forward [7-9].

Based on that, this paper makes further refining and carries out research on Liu Xiang 110m hurdle with targets. Apply multiple linear regressions in analyzing Liu Xiang 110m hurdle total performance correlations with start to first hurdle, hurdle step soaring, three-pace running, the last exertion such 4 stages. Use grey relational degree analysis to analyze Liu Xiang each stage performance merits, utilize mathematical statistics analyzing Liu Xiang and American players Johnson, Olivares hurdle striding time and average speed value, standard deviation. Finally, carry on comprehensive analysis and propose reasonable suggestions.

REGRESSION ANALYSIS ALGORITHM

Multiple linear regression models

Given expression between dependent variable y and independent variable x_1, x_2, x_3, x_4 is:

$$y = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 \tag{1}$$

Among them, y is observable random variable, b_0, b_1, b_2, b_3, b_4 are unknown parameters, ε is unobservable random error, meet $E_\varepsilon = 0, D(\varepsilon) = \sigma^2 (\sigma^2 is unknown)$, but ε random error is quite small, so it can be ignored by comparing actual.

From 9 groups data, $(y_j, x_{1j}, x_{2j}, x_{3j}, x_{4j})(j = 1,2,\cdots,9)$, from which x_{ij} is independent variable x_i the j value, y_j is dependent variable y the j value, input formula(1)can get model data structural formula:

$$\begin{cases} y_1 = b_0 + b_1 x_{11} + b_2 x_{21} + b_3 x_{31} + b_4 x_{41} \\ y_2 = b_0 + b_1 x_{12} + b_2 x_{22} + b_3 x_{32} + b_3 x_{42} \\ \vdots \\ y_n = b + b_0 x_{1n} + b_1 x_{2n} + b_3 x_{3n} + b_4 x_{4n} \end{cases} \tag{2}$$

The above formula (2) can use matrix to express formula as:

$$Y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} \qquad X = \begin{bmatrix} 1 & x_{11} & \cdots & x_{41} \\ 1 & x_{12} & \cdots & x_{42} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_{1n} & \cdots & x_{4n} \end{bmatrix} \qquad B = \begin{bmatrix} b_0 \\ b_1 \\ \vdots \\ b_n \end{bmatrix}$$

$$Y = XB$$

Unknown parameters estimations

Make use of least square method, according to SPSS software can work out:

$$b_0 = 0.996 \quad b_1 = -0.177 \quad b_2 = 1.290 \quad b_3 = 0.040 \quad b_4 = 1.316$$

Therefore determine multiple linear regression equation as:

$$y = 0.996 - 0.177 x_1 + 1.29 x_2 + 0.04 x_3 + 0.316 x_4 \tag{3}$$

Regression equation significance testing

Multiple linear regression equation F test purpose is to test total regression equation is significant or not, which is testing whether all regression coefficients is equal to 0 or not. The concrete steps as following:

(1) Put forward null hypothesis as well as alternative hypothesis:

$$H_0 : b_{ij} = 0, (i = 1,2,3,4; j = 1,2,\cdots.9) \qquad H_1 : b_{ij} \text{Not all of } 0,, (i = 1,2,3,4; j = 1,2,\cdots,9)$$

(2) According to variance analysis (ANOVA)Table 1, it gets F statistical value as 0, corresponding Sig. is value F actual significance probability that is value p, Sig. <0.001 here. If defined α =0.01, it is obvious that p< α , therefore refuse H^0 , it is thought that regression equation linear correlation is significant.

Table 1: Variance analysis table (ANOVA[b])

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.252	4	.063	106.149	.000a
	Residual	.002	4	.001		
	Total	.254	8			
a. Predictors: (Constant), spurt, soaring time, run to the first hurdle, three-pace running						
b. Dependent Variable: total time						

Regression coefficients testing

Regression coefficients significant testing t test, which is to test whether independent variable (explanatory variable) x_i influences on dependent variable y is significant or not. The steps are as following:

(1) Put forward null hypothesis as well as alternative hypothesis:

$H_0 : b_j = 0 (j = 1,2,\cdots,9)$ $H_1 : b_j \neq 0 (j = 1,2,\cdots,9)$

(2) It needs to carry out significant testing on every regression coefficient.

Table 2: Regression coefficient (Coefficients [a])

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Co linearity Statistics	
		B	Std.Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.996	.682		1.462	.218	-.896	2.889					
	run to first hurdle	-.177	.273	-.065	-.647	.553	-.935	.582	.746	-.308	-.031	.231	4.338
	Soaring time	1.290	.120	.943	10.768	.000	.958	1.623	.673	.983	.520	.305	3.284
	Three-pace running	1.316	.165	.808	8.000	.001	.860	1.773	.499	.970	.386	.229	4.373
	Spurt	.040	.413	.006	.096	.928	-1.108	1.188	.317	.048	.005	.511	1.957
a. Dependent Variable: Total time													

From above Table 2 four variables, run to first hurdle x_1, hurdle step soaring x_2, three-pace running x_3 the last exertion x_4, their Sig. are respectively:0.553, 0.000, 0.001, 0.928, their corresponding Sig. is value t actual significance level that is value p, if defined $\alpha = 0.01$:

$p_1 = 0.553 > \alpha$ so it accepts H_0, thought the independent variable “run to the first hurdle” regression coefficient is not significant.

$p_2 = 0.000 < \alpha$ so it refuses H_0, thought independent variable” hurdle step soaring” regression coefficient is significant.

$p_3 = 0.001 < \alpha$ so it refuses H_0, thought independent variable” three-pace running” regression coefficient is significant.

$p_4 = 0.928 > \alpha$ so it accepts H_0, thought independent variable” the last exertion” regression coefficient is significant.

From above conclusions, it can know that hurdle performance y and hurdle-step soaring x_2, three-pace running x_3 have higher significance and big influences on total performance, while other two items have lower significance so that it has smaller influences on total performance.

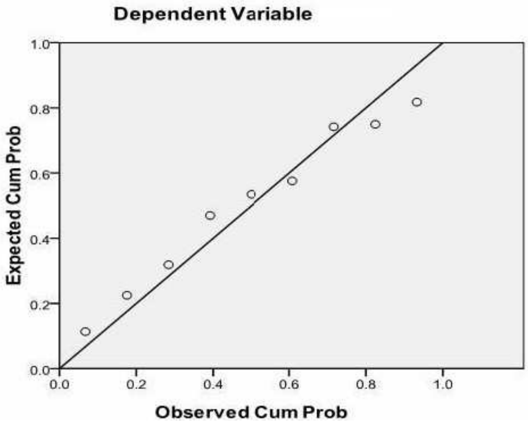

Figure 1: Normal P-P Plot of Regression Standardized Residual

Due to most of scatter points close to diagonal line, it is thought that standardized residual is conforming to normal distribution.

By regression result and analysis results repeatedly testing, it got that hurdle performance is only correlated to hurdle step soaring x_2 and three-pace running x_3 so that consider hurdle performance regression linear correlations with hurdle step soaring x_2 and three-pace running x_3.

GREY RELATIONAL DEGREE ANALYSIS MODEL ESTABLISHMENT AND SOLUTION

Correlation degree calculation

Apply grey relational degree analysis method in implementing comprehensive evaluation; its core is calculating correlation degree. Generally speaking, correlation degree calculation should first handle with original data, then work out correlation coefficient so that can calculate correlation degree.

(1) Original data handling:

Due to each factor has different calculation unit, original data has differences in dimension and magnitudes order, different dimensions and magnitudes order are not easier to make comparation, or it is hard to get correct conclusions. Therefore before correlation degree calculation, it usually should apply dimensionless in original data, its method is equalization.

Equalization: Firstly respectively work out each original series average number, then use series all data divides the series average number, get a multiple series that each data corresponds to average number that is equalization series.

(2) Calculate correlation coefficients:

Given reference series after data handling to be:

$$\{x_0(t)\} = \{x_{01}, x_{02}, \cdots, x_{09}\} \tag{4}$$

Correlation degree comparison p pieces of series with reference series (regular is called contrast series) are:

$$\{x_1(t), x_2(t), \cdots, x_p(t)\} = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{19} \\ x_{21} & x_{22} & \cdots & x_{29} \\ \cdots & \cdots & \cdots & \cdots \\ x_{p1} & x_{p2} & \cdots & x_{p9} \end{pmatrix} \tag{5}$$

From geometric perspective, correlation degree actually is reference series' similarity level with contrast series curve shape. In case the closer contrast series get to reference series curve shape, the bigger the two correlation degree would be; on the contrary, if the bigger curve shape differences are, then the smaller two correlation degree would be. Therefore, it can use differences among curves as correlation degree measurement criterion.

Record the k contrast series $(k = 1,2,3,\cdots 5, p)$ absolute value of differences that each phase value corresponds to reference series by phases as $a_{9k}(t) = |x_0(t) - x_k(t)|$, $t = 1,2,\cdots,9$. For the contrast series, respectively record 9 $a_{9k}(t)$ the minimum value and maximum value as $a_{9k}(\min)$ and $a_{9k}(\max)$; For p pieces of contrast series, record the minimum of p pieces $a_{9k}(\min)$ as $a(\min)$, the maximum of p pieces $a_{9k}(\max)$ as $a(\max)$, in this way $a(\min)$ and $a(\max)$ are respectively the maximum and minimum in all p pieces of contrast series absolute value in each phase, so that the k contrast series and reference series correlation degree at t period(it's usually called correlation coefficient)can work out through following formula.

$$\varsigma_{6k}(t) = a(\min) + \rho a(\max) = a_{9k}(t) + \rho a(\max) \tag{6}$$

In formula, ρ is resolution coefficient, which is used to weaken correlation coefficient distortion influence because of $a(\max)$ excessive large. Input the coefficient is to improve correlation coefficients difference correlation, $0 < \rho < 1$. It is clear that correlation coefficients reflect that two series depth of relationships in one period. For example, in the period that make $a_{9k}(t) = a(\min)$, $\varsigma_{9k}(t) = 1$, correlation coefficient arrives at the maximum; While in the period that make $a_{9k}(t) = a(\max)$, correlation coefficient arrives at the minimum. It is known that correlation coefficient change range is $0 < \varsigma_{9k}(t) \le 1$. It is obvious that when reference series length is 9, totally can work out $9 \times p$ pieces of correlation coefficients by p pieces of contrast series.

(3) Solve correlation degree:
Due to each contrast series and reference series correlation degree is reflected by 9 correlation coefficients, correlation information spreads that is not convenient to carry on overall comparison. Therefore, it is necessary to do concentration handling with correlation information. While average value is an information concentration way which is use contrast series and reference series each period correlation coefficients average value to quantitatively reflect the two series correlation degree, its computational formula is:

$$r_{9k} = \frac{1}{9}\sum_{t=1}^{9}\varsigma_{9k}(t) \tag{7}$$

In formula, r_{9k} is the k contrast series and reference series correlation degree? It is easily seen that correlation degree has relations with contrast series, reference series as well as its length. And original data dimensionless handling method is different from resolution coefficient selection, the correlation degree will also change.

(4) Sort correlation degree:
From above analysis, it is clear that correlation degree is just measurement among factors correlation comparison, which can only measure factors closely degree relative sizes, its values absolute sizes usually have little significance, the key point is to reflect each contrast series correlation degree with same reference series sizes. When contrast series have p pieces, corresponding correlation degree would have p pieces. Sort according to its values order, it will compose of correlation sequence. It reflects each contrast series and same reference series "primary and secondary", "good and bad" relations.

One of Grey correlation degree analysis method applications is factor analysis. In actual work, one economic variable has lots of influence factors. But due to objective realities are complicated, people recognition on things has data incompleteness and uncertainness, each factors influence on economic totals is not easier to make clear which needs to carry out further research, which is economic variable factor analysis. Apply grey correlation degree in factor analysis is very effective, and especially adapted to case that each influence factor and totals have no strictly mathematical relations.

Table 3: Phased time and total time

No.	run to first hurdle x_1	hurdle step soaring x_2	three-pace running x_3	The last exertion x_4	110m hurdle total time y
1	2.2000	3.5500	6.1600	1.4500	13.3600
2	2.2800	3.6200	6.0800	1.3400	13.3200
3	2.2400	3.5600	6.0500	1.3800	13.2300
4	2.2100	3.7000	5.9200	1.3800	13.2100
5	2.2100	3.4800	6.1000	1.3800	13.1700
6	2.2200	3.3500	6.1200	1.3700	13.0600
7	2.1800	3.5400	5.8600	1.3700	12.9500
8	2.0500	3.4500	5.8850	1.3700	12.9100
9	2.1400	3.2800	6.0800	1.3800	12.8800
Average value	2.192222	3.503333	6.028889	1.380000	13.121111

According data in Table 3, takes 110m hurdle total time as reference series $x_0(t)$, take running to first hurdler time $x_1(t)$, hurdle step soaring $x_2(t)$, three-pace running $x_3(t)$, the last exertion $x_4(t)$ as contrast series, work out 4 kinds of contrast series correlation degree with 110m hurdle total time.

Step 1: carry out average handling on each series. Average values of 110m hurdler total time and 4 kinds of contrast series are respectively:

$$x_0(t) = 13.121111 \quad x_1(t) = 2.192222 \quad x_2(t) = 3.503333 \quad x_3(t) = 6.028889 \quad x_4(t) = 1.380000$$

Respectively use above average values to divide each original data series get averaged series, refer to Table 4:

Table 4: Average processing series

No.	x_1	x_2	x_3	x_4	y
1	0.996465	0.986854	0.978716	0.951724	0.982119
2	0.961501	0.967772	0.991594	1.029851	0.985068
3	0.978671	0.984082	0.996511	1.000000	0.991770
4	0.991956	0.946847	1.018393	1.000000	0.993271
5	0.991956	1.006705	0.988342	1.000000	0.996288
6	0.987487	1.045771	0.985113	1.007299	1.004679
7	1.005607	0.989642	1.028821	1.007299	1.013213
8	1.069377	1.015459	1.024450	1.007299	1.016353
9	1.024403	1.068089	0.991594	1.000000	1.018720

Step 2: calculate each contrast series and reference series absolute difference in the same period. When number is 1,

$$a_{01}(1) = |0.982119 - 0.996465| = 0.014346$$
$$a_{02}(1) = |0.982119 - 0.986854| = 0.004735$$
$$a_{03}(1) = |0.982119 - 0.978716| = 0.003403$$
$$a_{04}(1) = |0.982119 - 0.951724| = 0.030395$$

Then respectively calculate rest each absolute differences. The whole results are as Table 5 shows. Find out maximum value and minimum value as:

$$a_{\max} = 0.053024 \qquad a_{\min} = 0.000894$$

Table 5: Absolute differences table

No.	x_1	x_2	x_3	x_4
1	0.014346	0.004735	0.003403	0.030395
2	0.023567	0.017297	0.006525	0.044782
3	0.013099	0.007687	0.004741	0.008230
4	0.001315	0.046424	0.025122	0.006729
5	0.004332	0.010417	0.007945	0.003712
6	0.017192	0.041092	0.019567	0.002620
7	0.007607	0.023571	0.015607	0.005914
8	0.053024	0.000894	0.008098	0.009053
9	0.005683	0.049370	0.027126	0.018720

Step 3: calculate correlation coefficient, value resolution coefficient $\rho = 0.2$, and then computation formula is:

$$\varsigma_{0i}(t) = \frac{a(\min) + 0.2a(\max)}{a_{0i} + 0.2a(\max)} = \frac{0.000894 + 0.2 \times 0.053024}{a_{0i} + 0.2 \times 0.053024} = \frac{0.0114988}{a_{0i} + 0.0106048} \tag{8}$$

When number is 1:

$$\varsigma_{01}(1) = \frac{0.0114988}{0.014346 + 0.0106048} = 0.460859$$
$$\varsigma_{02}(1) = \frac{0.0114988}{0.004735 + 0.0106048} = 0.749588$$
$$\varsigma_{03}(1) = \frac{0.0114988}{0.003403 + 0.0106048} = 0.820864$$
$$\varsigma_{04}(1) = \frac{0.0114988}{0.030395 + 0.0106048} = 0.280460$$

Use similar method to respectively calculate other each correlation coefficient, calculation results refer to, Table 6.

Table 6: Correlation coefficient calculation table

No.	x_1	x_2	x_3	x_4
1	0.460859	0.749588	0.820864	0.280460
2	0.336495	0.412120	0.671268	0.207608
3	0.485105	0.628626	0.749312	0.610494
4	0.964654	0.201631	0.321851	0.663378
5	0.769825	0.546991	0.619874	0.803160
6	0.413677	0.222428	0.381115	0.869487
7	0.631404	0.336460	0.438681	0.696106
8	0.180716	0.999910	0.614831	0.584941
9	0.705972	0.191728	0.304757	0.392121

Step 4: calculate correlation degree. Make use of Table 6, respectively solve each series each time correlation coefficients average value that is correlation degree.

$$r_{01} = \frac{1}{9}(0.460859 + 0.336495 + 0.485105 + 0.964654 + 0.769825 + 0.413677 + 0.631404 +$$
$$0.180716 + 0.705972) = 0.549856$$

$$r_{02} = \frac{1}{9}(0.749588 + 0.41212 + 0.628626 + 0.201630 + 0.546991 + 0.222428 + 0.33646 +$$
$$0.99991 + 0.191728) = 0.476609$$

$$r_{03} = \frac{1}{9}(0.820864 + 0.671268 + 0.749312 + 0.321851 + 0.619874 + 0.381115 + 0.438681 +$$
$$0.614831 + 0.304757) = 0.546950$$

$$r_{04} = \frac{1}{9}(0.280460 + 0.207608 + 0.610494 + 0.663378 + 0.803160 + 0.869487 + 0.696106 +$$

$0.584941+0.392121)=0.567528$

Step 5: sort correlation degree. From correlation values, it is clear that at this time $r_{04}>r_{01}>r_{03}>r_{02}$ it indicates four kinds of contrast series sequence order for 110m hurdler total time correlation degree are the last exertion, run to first hurdler time, three-pace running time, hurdle soaring time. It is last exertion time that dominates 110m hurdle total time, the influence of run to first hurdler time, three-pace running time, hurdler soaring time is secondary.

Apply grey correlation degree analysis method in comprehensive evaluation

The second application of grey correlation degree analysis method is used to carry out comprehensive evaluation. Basic idea is define an ideal optimal sample from samples by which as reference series. Through calculating each sample sequence and its reference sequence correlation degree, make comprehensive comparison and sorting on evaluated objects.

Given that n pieces of evaluated objects here, each evaluated objects have p pieces of evaluation indicators. In this way, the i evaluated targets can be described as:

$$x_i=\{x_{i1},x_{i2},\cdots,x_{ip}\},\quad i=1,2,\cdots,n.$$

(1) Define reference sequence

According to evaluation indicators economic definition, select each indicator optimal values to compose reference series from n pieces of evaluated objects x_o:

$$x_o=\{x_{o1},x_{o2},\cdots,x_{op}\}$$

Actually, reference series x_o composed of a relative ideal optimal sample that is comprehensive evaluation criterion. If the j item indicator is the positive indicator the larger value is the better would be, and then x_{oj} is the maximum value of n pieces of evaluated objects the item j indicator actual value; if it is reverse pointer, then it is the minimum value; if it is the moderate pointer, it is the moderate value of the pointer.

(2) Dimensionless handling

Dimensionless refers that eliminate original variable different dimensions influences through a certain mathematics transformation. Due to different influences by evaluated indicator dimensions and magnitude order, which enables each evaluation indicator has no comparative significance. Therefore, it must carry out dimensionless handling with each indicator actual value. Adopt linear type dimensionless formula that is:

$$x_{ij}=\frac{x_{ij}}{x_{0i}}\qquad i=1,2,\cdots,n,\ j=1,2,\cdots,p$$

At this time, each indicator optimal value is 1. To convenient for statement, let data after dimensionless handling still as x_{ij}, then optimal reference series is $x_0=\{1,1,\cdots,1\}$.

(3)Solve two-level maximum difference $a(\max)$ and two-level minimum difference $a(\min)$

Accordingly, it should first calculate absolute difference series between each evaluated objects series and most reference series. The computational formula:

$$a_{ij}=\left|x_{ij}-1\right|\qquad i=1,2,\cdots,n,\ j=1,2,\cdots,p$$

Based on that, according to formula:

$$a(\max)=\max_{0\le ij\le 1}(a_{ij})\qquad a(\min)=\min_{0\le ij\le 1}(a_{ij})$$

Can solve two-level maximum difference $a(\max)$ and two-level minimum difference $a(\min)$.

(4)Calculate correlation degree

Computational formula: $\varsigma_{ij} = \dfrac{a(\min) + \rho a(\max)}{a_{ij} + \rho a(\max)}$.

Calculate correlation degree between the i evaluation objects and optimal reference series.

(5)Comparison and sorting

Due to r_i reflect mutual correlation degree the i evaluated objects and evaluation standard series x_0, therefore, if $E_i > E_j$, then shows that the i sample is better than the j sample. So according to $\{E_i\}$ can make sorting and comparison on evaluated objects.

STATISTICAL ANALYSIS

Statistics: Assume one sample with n capacitor (that is a group of data), record as $x = (x_1, x_2, \cdots, x_n)$ that needs to carry out a certain processing so that can extract useful information functioning as total(distribution) parameters' estimation and testing. Statistics is processed sample quantity feature reflection function that doesn't include any unknowns.

(1)Represents position statistics- arithmetic average value

Arithmetic average value (is called average value for short) describing data values average position, record as $\overline{x}$:

$$\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{9}$$

(2)Represents variation degree statistics-standard deviation, the definition of standard deviation s is:

$$s = \left[\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2\right]^{\frac{1}{2}} \tag{10}$$

It is each data and average value deviation degree measurement; the deviation can be called as variation.

Liu Xiang and Johnson, Olivares whole journey hurdler running hurdler striding time, speed and total performance contrasting analysis

Table 7: Liu Xiang and two world excellent players' hurdler striding time (time: s)

Name	Hurdler 1	Hurdler 2	Hurdler 3	Hurdler 4	Hurdler 5	Hurdler 6	Hurdler 7	Hurdler 8	Hurdler 9	Hurdler 10	Spurt	Total performance
Liu Xiang	2.56	1.03	1.00	0.98	1.01	1.00	1.02	1.02	1.03	1.04	1.37	13.06
Johnson	2.56	1.02	1.02	1.00	0.98	1.00	1.02	1.00	1.02	1.04	1.40	13.06
Olijars	2.58	1.02	1.00	1.00	0.98	1.00	1.02	1.00	1.04	1.06	1.38	13.08

From above Table 7 can solve Liu Xiang, Johnson, Olijars three people hurdle striding time average time from hurdle 1 to hurdle 10 that respectively as 1.01444s, 1.01111s, 1.01333s, while standard deviation are respectively 0.018782, 0.017638, 0.024495. Results indicates that in spurt stage Liu Xiang has remarkable advantages, but time from hurdler 1 to 10 is longer than Johnson and Olivares, standard deviation is slightly larger than Johnson. Hurdle striding time divides into hurdle time and three-pace running time. To improve hurdler performance, it needs to shorten hurdler cross time and three-pace running time, hurdle soaring reflects players hurdle crossing techniques merits. Liu Xiang should take targeted strengthen hurdler soaring techniques training so as to get good results in future competitions.

Table 8: Liu Xiang and two world excellent players' hurdler striding speed (speed: m/s)

Name	Hurdler1	Hurdler 2	Hurdler 3	Hurdler 4	Hurdler 5	Hurdler 6	Hurdler 7	Hurdler 8	Hurdler 9	Hurdler 10	Spurt	Total performance
Liu Xiang	5.36	8.89	9.14	9.24	9.12	9.14	8.96	8.96	8.89	8.79	10.20	13.06
Johnson	5.36	8.96	8.96	9.14	9.33	9.14	8.96	9.14	8.96	8.79	10.01	13.06
Olijars	5.32	8.96	9.14	9.14	9.33	9.14	8.96	9.14	8.79	8.62	10.16	13.08

From above Table 8 can solve Liu Xiang, Johnson, Olijars three people hurdle striding average speed from hurdle 1 to hurdle 10 that respectively as 9.01444m/s, 9.04222m/s, 9.02444m/s, while standard deviation are respectively 0.150342, 0.158964, 0.216108. Results indicates that in spurt stage Liu Xiang has fastest speed, speed average value from hurdler 1 to 10 is slightly slower than Johnson and Olijars and gets the minimum standard deviation. Liu Xiang should based on speed stability speeds up hurdle speed especially from hurdler 3 to 5 so as to get good results in future competitions.

Liu Xiang Hurdler yearly average performance and stability analysis

Table 9: Liu Xiang years' average results

Periods/year	Average performance/s	Standard deviation	Stability
2002	13.4133	0.235089	4.2537
2003	13.3478	0.188068	5.3172
2004	13.1918	0.150387	6.6495
2005	13.1773	0.155441	6.4333
2006	13.1120	0.133483	7.4916
2007	13.1500	0.136235	7.3403
2008	13.1900		
2009	13.4125	0.218384	4.5791
2010	13.2450	0.219203	4.5620
2011	13.1740	0.133154	7.5101
2012	12.9767	0.110151	9.0784

At first, according to Liu Xiang 110 hurdle years' average performance and performance (Table 9) stability figures Figure 2, Figure 3 so as easier to analysis.

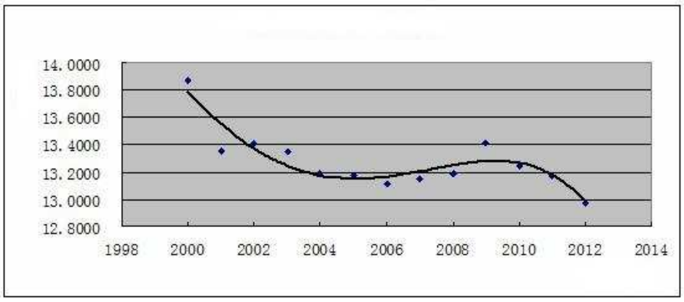

Figure 2: Liu Xiang 110m hurdler yearly average performance

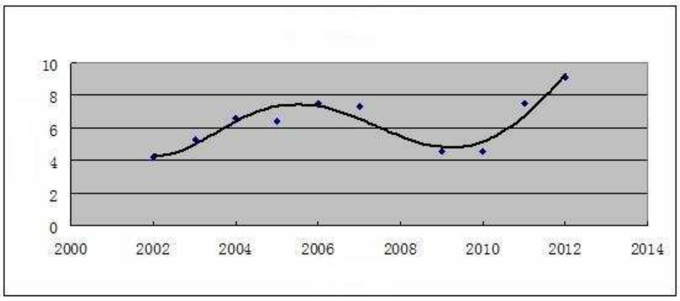

Figure 3: Liu Xiang yearly performance stability

From Liu Xiang 110m hurdler yearly average performance can found that though Liu Xiang performance fluctuates, totally it would turn up increasing tendency, performance stability changes show that Liu Xiang performance gradually tends to stable in fluctuating.

CONCLUSION

Through regression analysis, 110m hurdle performance and hurdle step soaring, three-pace running have significant correlations; Grey correlation degree analysis 110m hurdle performance is dominated by the last exertion. Integrate the two items research can know that it is hurdle step soaring, three-pace running have significant correlations with performance which Liu Xiang are not good at. Therefore Liu Xiang performance improving directions are maintain last exertion advantages, improve hurdle soaring, three-pace running speed. Suggest effective control gravity center when hurdling, increase maximum speed as well as maintain high speed capacity, speed up running rhythms between hurdles so as to ensure effective improving speed. Through analyzing and researching on Chinese excellent players Liu Xiang yearly performance, total performance can already regarded as excellent, but hurdler striding speed has slightly shortcomings. If it wants to make further improvement base on that, it needs to keep speed stability and spurt advantages meanwhile strengthen soaring hurdler crossing and three-pace running speed. Suggest that strengthen hurdler training and improve hurdler speed as well as maintain high speed hurdler capacity when taking exercises,

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