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## Chinese and foreign men's decathlon each single event performance features comparative analysis based on grey relational degree

Weizeng Yin\*, Deli Zhang and Youzhong Chen

Physical Education Department, Anhui Agricultural University, Hefei 230036, Anhui, (CHINA)

### ABSTRACT

The paper uses document literature, grey relational analysis and comparative analysis to count men's decathlon best performances for 9 years from 2005 to 2013 and Chinese the 11<sup>th</sup> national games men's decathlon competition top nine performances. Result shows that Chinese decathlon athletes adept sports events class groups are successively jumping type, throwing type, speed type and endurance type, which is different from world top decathlon athlete adept class groups, they have larger development space, from which endurance type weight is higher that of world top athletes by comparing, speed type and throwing type occupied weights are lower that need to be focused on their development. Chinese athlete total performance and each event performance still keeps larger paces with world top athlete, each event has certain development space.

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### KEYWORDS

Men's decathlon;  
Grey relational analysis;  
Factor analysis;  
Performance features.

### INTRODUCTION

Decathlon is one kind of all-round event in athletics that is composed of 10 sports events include running, jumping, throwing and other aspects sports events. Decathlon competition is going by two days, events are many and difficulties are big, which has serious requirements with athlete speed, sensitivity and endurance so on, and it also has high requirements on athlete's psychological qualities, even is called "ironman" sport event. At present, Chinese decathlon athlete level keeps certain paces with world athlete level, the gap is even enlarging, and how to improve Chinese decathlon athlete sport level has become a problem that allows no delay.

Men's decathlon is composed of ten events, every event will affect athlete total performance, research on

every event contribution rate on total performance and Chinese athlete gap with world athlete in every event is the key to analyze Chinese decathlon athlete weakness and guide Chinese athlete to improve competition performance. Analyze decathlon each single event to total performance contribution rate and make comparison on the gap between Chinese and foreign excellent decathlon athlete have many methods, and lots of scholars have already carried out lots of researches. Research methods mainly are regression analysis, variance analysis, principal component analysis and other mathematical statistics methods, and also have grey relational analysis as well as other newly-developed mathematical methods. Among them, Ma Xiang-Hai (2012) researched on Chinese excellent decathlon athlete performance, by carrying out grey relational analysis on it

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and grey GM(1,1) prediction model's modeling, he analyzed Chinese decathlon athlete development trend<sup>[1]</sup>; Wang Xin-Peng, Liu Feng-Jun(2010) by making grey relational analysis of Chinese decathlon excellent athlete Qi Hai-Feng and foreign world level decathlon athlete performances, they put forward Qi Hai-Feng decathlon dominant events and guided his training<sup>[2]</sup>; Wang Xin-Peng, Tao Hong (2013) adopted grey coordination analysis and other methods to make comparative analysis of foreign world level excellent decathlon athlete and Chinese excellent decathlon athlete, they proposed Chinese and foreign athletes' competition performance development overall levels differences<sup>[3]</sup>; Liu Jia-Jin(2004) applied regression analysis and factor analysis as well as other methods to analyze Chinese decathlon athletes each influence element, and found out main reasons that provided guiding directions for China future decathlon athlete training<sup>[4]</sup>; Li Qing-Jian, Zhang Yi-Hang, Ran Qing-Quan(2013) by statistical analysis of each major match men's decathlon performance from 2008 to 2011, they presented suggestions that excellent decathlon athlete should major in all-round development, which provided references for Chinese men's decathlon training<sup>[5]</sup>.

The paper counts world men's decathlon annual best performances from 2005 to 2013 and the 11<sup>th</sup> national game men's decathlon top nine athletes' performance, carries out grey relational analysis and comparative analysis of them, and researches on Chinese men's decathlon athlete and world level athlete performance structure as well as each single event performance differences, in the hope of providing references

for men's decathlon development.

### WORLD MEN'S DECATHLON PREVIOUS BEST PERFORMANCE STRUCTURAL ANALYSIS

In order to analyze world level excellent men's decathlon athletes' performance structure and research on each single event to its total performance influence, the paper makes statistics of world men's decathlon annual best performances for 9 years from 2005 to 2013, and on this basis, it carries out grey relational analysis, its statistical data is as TABLE 1.

#### World men's decathlon previous best performances grey relational degree

In order to more effective analyze decathlon each single event performance and total performance relations, it adopts grey relational analysis to analyze it.

(1) Adopt previous total performance sequence as reference sequence that main factor is decathlon total performance sequence  $x_0$ , and then by TABLE 1 data, it generates sequence:

$$y_0 = (8732, 8677, 8697, 8832, 8790, 8483, 8729, 9039, 8809)$$

Decathlon included ten events are respectively grey relational analysis sub factors, 100m, long jump, shot, high jump, 400m, 110m hurdle, discus, pole vault, javelin throw and 1000m each single event generated sequence are successively  $y_1, y_2, \dots, y_{10}$ .

(2) In men's decathlon statistics data, each single event performance hasn't converted into unified perfor-

TABLE 1: 2005~2013 previous world men's decathlon highest performances table<sup>[6]</sup>

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total performance	8732	8677	8697	8832	8790	8483	8729	9039	8809
100m	10.43	10.42	10.94	10.39	10.45	10.35	10.33	10.21	10.35
Long jump	7.54	7.67	7.84	7.39	7.83	7.51	7.8	8.23	7.73
Shot	16.25	15.56	16.47	15.17	15.33	15.38	14.14	14.20	14.39
High jump	2.00	2.06	2.12	2.08	1.99	2.06	2.05	2.05	1.93
400m	47.78	48.87	48.99	48.41	48.13	49.66	46.35	46.70	46.02
110m hurdle	14.43	13.74	14.39	13.75	13.86	14.08	13.52	13.70	13.72
Discus	53.68	52.21	47.66	52.74	48.08	49.85	41.58	42.81	45.00
Pole vault	4.90	5.00	4.80	5.00	5.20	4.6	5.05	5.30	5.20
Javelin throw	72.00	66.47	68.87	70.55	68.00	66.1	56.19	58.87	64.83
1500m	303.77	313.47	280.44	290.97	288.01	296.37	264.10	254.48	269.80

mance, each dimension is different. To make grey relational analysis of it, it can carry out initialize processing with it. For total performance, long jump, shot, high jump, discus, pole vault and javelin throw, their performance value gets bigger, it shows its performance gets higher, so when initializes it, processing formula is :

$$x_i = (1, \frac{y_i(2)}{y_i(1)}, \dots, \frac{y_i(9)}{y_i(1)}) , i = 0,2,3,4,7,8,9$$

And to 100m,400m,110m hurdle,100m and other sports events, then performance value gets lower, its performance becomes higher, so initializes it and can adopt data processing formula:

$$x_i = (1, \frac{y_i(1)}{y_i(2)}, \dots, \frac{y_i(1)}{y_i(9)}) , i = 1,5,6,10$$

It can get data after initializing as TABLE 2.

- (3) Handle with TABLE 2 data, solve main sequence and each item sub sequence difference absolute values, and screen maximum value and minimum value in each item sub sequence and main sequence difference absolute value. By calculating TABLE 2 data, it can solve maximum value and minimum value:

$$\min_i \min_k |x_0(k) - x_i(k)| = 0$$

$$\max_i \max_k |x_0(k) - x_i(k)| = 0.2377$$

- (4) Solve main sequence  $x_0$  and sub sequence  $x_i$  each item correlation coefficient  $\xi_i(k)$ , it can solve by

formula:

$$\xi_i(k) = \frac{\min_s \min_k |x_0(k) - x_i(k)| + \rho \max_s \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \max_s \max_k |x_0(k) - x_i(k)|}$$

From which  $\rho$  is resolution ratio, and the value gets bigger, resolution ratio will also get bigger, here takes  $\rho = 0.5$ . Input TABLE 2 data into above formula, it can solve main sequence  $x_0$  and each event sub sequence  $x_i (i = 1,2, \dots, 10)$  correlation coefficient as TABLE 3.

- (5) In order to easy to calculate and analyze, let TABLE 3 solved correlation coefficient formula:

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

Among them,  $r_i$  is each item sub sequence and main sequence correlation degree, it can solve each sub sequence and main sequence correlation degree, as TABLE 4.

Set  $R_i$  is each sub sequence correlation degree weight value, by formula and each item sub sequence as well as main sequence correlation degree values, it can solve:

$$R_i = r_i / \sum_{k=1}^n r_k$$

It solves each item sequence correlation degree weight value as TABLE 5.

TABLE 2 : 2005~2013 previous world men's decathlon highest performance initialize values table

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
$x_0$	1	0.9937	0.9960	1.0115	1.0066	0.9715	0.9997	1.0352	1.0088
$x_1$	1	1.0010	0.9536	1.0038	0.9981	1.0078	1.0097	1.0216	1.0078
$x_2$	1	1.0172	1.0398	0.9801	1.0385	0.9960	1.0345	1.0915	1.0252
$x_3$	1	0.9575	1.0135	0.9335	0.9434	0.9465	0.8702	0.8738	0.8855
$x_4$	1	1.0300	1.0600	1.0400	0.9950	1.0300	1.0250	1.0250	0.9650
$x_5$	1	0.9777	0.9753	0.9870	0.9928	0.9622	1.0308	1.0231	1.0382
$x_6$	1	1.0502	1.0028	1.0494	1.0411	1.0249	1.0673	1.0533	1.0517
$x_7$	1	0.9726	0.8879	0.9825	0.8957	0.9287	0.7746	0.7975	0.8383
$x_8$	1	1.0204	0.9796	1.0204	1.0612	0.9388	1.0306	1.0816	1.0612
$x_9$	1	0.9232	0.9565	0.9799	0.9444	0.9181	0.7804	0.8176	0.9004
$x_{10}$	1	0.9691	1.0832	1.0440	1.0547	1.0250	1.1502	1.1937	1.1259

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TABLE 3 : Each single event and total performance correlation coefficient table

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
$x_1$	1	0.9424	0.7361	0.9399	0.9328	0.7663	0.9222	0.8972	0.9909
$x_2$	1	0.8437	0.7307	0.7913	0.7888	0.8288	0.7733	0.6783	0.8788
$x_3$	1	0.7667	0.8713	0.6040	0.6526	0.8261	0.4785	0.4242	0.4908
$x_4$	1	0.7660	0.6499	0.8063	0.9108	0.6700	0.8242	0.9212	0.7306
$x_5$	1	0.8813	0.8517	0.8293	0.8952	0.9271	0.7921	0.9081	0.8015
$x_6$	1	0.6777	0.9460	0.7577	0.7751	0.6900	0.6372	0.8676	0.7346
$x_7$	1	0.8493	0.5235	0.8040	0.5171	0.7350	0.3455	0.3333	0.4017
$x_8$	1	0.8165	0.8787	0.9299	0.6852	0.7482	0.7933	0.7188	0.6993
$x_9$	1	0.6276	0.7505	0.7900	0.6564	0.6898	0.3515	0.3533	0.5229
$x_{10}$	1	0.8282	0.5768	0.7850	0.7119	0.6896	0.4411	0.4284	0.5037

TABLE 4 : Each item sub sequence and main sequence correlation degree value

Indicator	$r_1$	$r_2$	$r_3$	$r_4$	$r_5$	$r_6$	$r_7$	$r_8$	$r_9$	$r_{10}$
Correlation degree	0.683	0.901	0.874	0.818	0.669	0.642	0.808	0.808	0.796	0.617

TABLE 5 : Each item sub sequence and main sequence correlation degree weight value

Indicator	$R_1$	$R_2$	$R_3$	$R_4$	$R_5$	$R_6$	$R_7$	$R_8$	$R_9$	$R_{10}$
Weight value	0.089	0.118	0.115	0.107	0.087	0.084	0.106	0.106	0.104	0.084

### World men's decathlon features analysis

By analyzing and researching on world men's decathlon annual best performances from 2005 to 2013, it is clear that each single event to world men's decathlon athlete sports total performance influence order from strong to weak is :long jump, shot, high jump, discus, pole vault, javelin throw, 100m, 400m, 110m hurdle, 1500m. Among them, long jump to total performance correlation degree surpasses 0.9, is strongest influence sport event to total performance. Shot, high jump, discus and pole vault all these four events correlation degrees surpass 0.8. These five sports to world level men's decathlon athlete performance influence are the biggest. The other five events have relative little influences on total performance, 100m, 400m, 110m hurdle and 1500m correlation degree is less than 0.7, relative to correlation degree top five sport events, their impact are relative little.

Men's decathlon ten sports events have different requirements on athlete's each physical ability, and it has requirements on athlete's strength, speed, endurance and spring as well as other aspects physical qualities. Due to physical qualities differences, different ath-

letes' adept events are surely different. By TABLE 5 data, it is clear that to men's decathlon world level top athlete, they adept in long jump, high jump and pole vault and other horizontal springing events as well as shot, discus and javelin throw and other throwing type event, these events have higher requirements on lower limbs explosive power body strength. Among them, long jump, high jump and pole vault performance correlation degree weight values on total performance in decathlon respectively rank the first, the third and the fifth, shot, discus and javelin throw these three events respectively rank the second, the fourth, the sixth. Throwing type and jumping type six events correlation degree to total performance occupies top six of decathlon, therefore it can see the importance of world level top athletes. And 100m, 400m and 110m hurdle as well as other speed type event, and 1500m speed endurance event, their correlation degrees rank the late four, which shows that to world level top athletes, speed sport and endurance sport impacts on the total performance is relative weak.

### CHINESE MEN'S DECATHLON PERFOR-

**MANCE STRUCTURAL ANALYSIS**

The paper makes statistics of the 11<sup>th</sup> national games Chinese men’s decathlon performance top ten athletes’ performances, applies grey relational analysis to calculate and make analysis and comparison of decathlon total scores and each single event performance, researches on Chinese men’s decathlon athletes’ sports performance internal structure, and analyzes each single event contributions to Chinese men’s decathlon total performance. Chinese 11<sup>th</sup> national games men’s decathlon top ten performance statistics is as TABLE 6.

**Chinese men’s decathlon performance grey relational calculation**

According to former research, it calculates world men’s decathlon annual best performance total score

and each single event correlation degree method from 2005 to 2013, and calculates Chinese 11<sup>th</sup> men’s decathlon athletes’ total performance and each single event correlation degrees.

- 1) Same as world level top men’s decathlon athletes’ performance correlation degree calculation method, set Chinese athlete total performance as main sequence, other each single event performance as sub sequence. For each event performance dimension is not unified, initialize its each single event performance. Its initialized method likes world level top men’s decathlon athletes’ performance initialized method.
- 2) Input after initializing each item data into corresponding formula, it can solve each single event performance and total performance correlation degree, as TABLE 7.

**TABLE 6 : The 11<sup>th</sup> national games men’s decathlon top ten performances**

Rank	1	2	3	4	5	6	7	8	9
Total value	7941	7791	7708	7427	7370	7346	7261	7256	7106
100m	10.86	10.85	10.70	11.35	11.28	11.49	11.12	11.28	11.25
Long jump	7.38	7.53	7.17	6.98	6.82	7.09	7.11	7.10	7.14
Shot	13.51	14.24	13.71	13.09	13.85	13.92	12.32	13.44	12.87
High jump	2.00	1.91	1.88	2.12	2.03	1.88	1.82	2.09	1.91
400m	49.27	50.05	48.74	50.79	51.50	52.38	49.99	52.79	50.46
110m hurdle	14.82	14.69	14.24	15.15	15.05	15.12	15.06	15.47	14.83
Discus	45.06	44.34	38.58	42.35	41.31	46.57	40.69	37.90	34.77
Pole vault	4.50	4.20	4.50	4.00	4.70	4.40	4.30	4.10	4.20
Javelin throw	60.92	62.23	57.85	55.35	47.05	60.33	56.10	54.66	49.71
1500m running	286.10	294.29	293.04	286.61	292.35	306.80	293.10	288.45	294.66

**TABLE 7 : Each single event and total performance correlation coefficient table**

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
$x_1$	1	0.7972	0.6375	0.7832	0.6920	0.7949	0.5558	0.6137	0.5249
$x_2$	1	0.6651	0.9888	0.8809	0.9514	0.6861	0.6136	0.6171	0.5175
$x_3$	1	0.5165	0.6382	0.6984	0.4452	0.4252	0.9695	0.4900	0.5741
$x_4$	1	0.7489	0.7175	0.3844	0.4726	0.8392	0.9469	0.3724	0.5642
$x_5$	1	0.9593	0.6595	0.6912	0.7314	0.8335	0.5223	0.7991	0.4885
$x_6$	1	0.7374	0.5264	0.6446	0.5790	0.5857	0.5277	0.6377	0.4271
$x_7$	1	0.9640	0.4049	0.9444	0.8731	0.4180	0.8728	0.5174	0.3873
$x_8$	1	0.6198	0.7264	0.6267	0.4010	0.5964	0.6541	0.9674	0.6693
$x_9$	1	0.6585	0.7872	0.7447	0.3333	0.5442	0.9228	0.8252	0.4969
$x_{10}$	1	0.8970	0.9323	0.5532	0.6065	0.9126	0.5578	0.4993	0.5058

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- 3) By calculating correlation degrees values formula, it can solve Chinese 11<sup>th</sup> national games, men's decathlon athletes' each single event and total performance correlation degree as TABLE 8.
- 4) In order to compare each single event performance and total performance relations, convert each single event and total performance correlation degree value into correlation degree weight value as TABLE 9 here.

### Chinese men's decathlon features analysis

By TABLE 8, it is clear that in Chinese men's decathlon athlete correlation values, long jump, 400m, 1500m, 100m, discus and javelin throw as well as other single event and total performance correlation degrees surpass 0.7, and Chinese each single event correlation degree difference is relative smaller, from which long jump correlation degree coefficient is 0.769, 400m correlation coefficient is 0.743, the two sports correlation coefficients are higher by comparing with other sports events, which has largest effects on Chinese athletes' total performance. But Chinese athletes' pole vault and high jump performance and total performance correlation degrees are respectively 0.696 and 0.672, which rank the seventh and eighth in decathlon correlation degrees, it shows Chinese athletes' spring ability is still relative weak and needs to be developed.

By TABLE 9, it is clear that Chinese men's decath-

lon athletes' competition performance, total performance each influence single event, impact order from strong to weak is long jump, 400m, 1500m, 100m, discus, javelin throw, pole vault, high jump, shot and 110m hurdle. Chinese athletes' 1500m and total performance correlation degree has already ranked the fourth in decathlon correlation degrees; it has higher impact on total performance. And to total performance stronger impacts several events, only long jump is in jumping type event. Chinese athletes' throwing type events correlation coefficient weights are relative larger, from which discus and javelin throw correlation degree weight values are respectively 0.101 and 0.100, which rank the fifth and sixth in decathlon. Chinese speed type sports three events, they rank the second, the fourth and the tenth in weight values, on a whole, they have big influences on Chinese athletes' total performance, and need Chinese athletes to maintain their fitness in the type of events. Meanwhile, in the dominant top several events among Chinese athletes, there is jumping type event, and also speed type event as well as endurance type event; comparing with world level athletes, overall development is relative balanced. But meanwhile it also shows that Chinese athletes' physical qualities and technical levels haven't arrived at level as they should have, physical qualities is needed to be improved, each single event has larger development space.

TABLE 8 : Chinese 11<sup>th</sup> national games men's decathlon total scores and each single event correlation degree

Indicator	$r_1$	$r_2$	$r_3$	$r_4$	$r_5$	$r_6$	$r_7$	$r_8$	$r_9$	$r_{10}$
Correlation degree	0.711	0.769	0.640	0.672	0.743	0.630	0.709	0.696	0.701	0.718

TABLE 9 : Chinese athletes' each single event and total performance correlation degree weight value

Indicator	$R_1$	$R_2$	$R_3$	$R_4$	$R_5$	$R_6$	$R_7$	$R_8$	$R_9$	$R_{10}$
Weight	0.102	0.110	0.092	0.096	0.106	0.090	0.101	0.099	0.100	0.104

### CHINESE AND FOREIGN MEN'S DECATHLON PERFORMANCE DIFFERENCE ANALYSIS

Chinese men's decathlon performance compares to world level top athletes, it has larger differences; analyze Chinese athletes' and world level athletes' differences are the key to improve Chinese athletes' performance.

### Chinese athletes and world level athletes' perfor-

### mance structural analysis

Men's decathlon's ten competition sports can be divided into four main groups. That is speed type, jumping type, throwing type and endurance type. Among them, speed type includes 100m, 100m hurdle and 400m, jumping type includes high jump, long jump and pole vault, throwing type includes shot, discus and javelin throw, endurance type is 1500m. In order to more effective compare Chinese men's decathlon athletes and world top athletes' differences, respectively solve world top athletes and Chinese athletes weight values in the

four groups here that respectively add four groups' all items' weights and solve their sum. World top men's decathlon athletes four groups that speed type, jumping type, throwing type and endurance type weight values are respectively 0.260, 0.331, 0.325, 0.084. Chinese men's decathlon athletes' four groups' weights are respectively 0.298, 0.305, 0.293 and 0.104.

By comparing Chinese decathlon athlete and world level decathlon athlete weights in each group, it is clear that all world level top decathlon athletes adept in throwing type and jumping type. Chinese athlete weight proportion in jumping type and throwing type has larger differences with world level top athletes; it shows they still have great development space in jumping type and throwing type sports events. Different from world level top athletes, Chinese athlete 1500m event has relative higher correlation coefficient weight values to total performance. To world top athlete, its 1500m performance correlation coefficient to total performance in the ten events, it ranks the tenth, and Chinese athlete 1500m correlation coefficient ranks the third. Meanwhile, relative to world level top athlete, Chinese athlete each group sports event development is also relative balanced. To world level athlete, his speed type event's three events that 100m, 400m and 110m hurdle correlation coefficient all rank the seventh, eighth and ninth in decathlon, and Chinese these three events correlation coefficient rank the fourth, the second and the tenth in decathlon. World level top athlete same type sport event correlation degree to total performance has no big differences that same type sport event contribution rate to total performance has no big differences. Therefore, it can see that world level top athlete performance each single event's performance stability is strong and also arrives at relative high level. And Chinese athlete performance is not stable, development space is bigger.

### **Chinese athlete and world level athlete performance comparison**

By comparing scores, it is clear that Chinese athletes keep larger paces with world level top athletes in each type sport event. In speed type competition event, they also keep larger paces with world level top athletes, event in jumping type and throwing type events, Chinese athletes also cannot against world level athletes.

Take Chinese men's decathlon master sportsman Qi Hai-Feng as an example, Qi Hai-Feng got the fourth performance with 8290 scores in international athletic decathlon challenge in May, 2005, but he had above 1000 scores difference with world record holder total score 9093 scores. Make comparison on Qi Hai-Feng and O'Brien each single event best performances. To Chinese athlete adept throwing sports, Qi Hai-Feng's discus, javelin throw and shot best performances are respectively 48.34m, 61.04m and 13.3m, and O'Brien performances on these three events are respectively 55.07m, 66.90m and 16.69m. Even to world level top athlete total performance lower correlation degree speed type event, Chinese athlete also keeps larger paces with world level top athlete. As Qi Hai-Feng 100m, 400m and 110m hurdle best performances are respectively 11.06s, 49.09s and 14.54s, and O'Brien sport performances in the three events are respectively 10.23s, 46.53s and 13.47s. Therefore, it is clear that Chinese decathlon athlete and world level decathlon athlete differences are comprehensive.

### **CONCLUSIONS**

Apply grey relational analysis, it can analyze Chinese and world level top men's decathlon athletes' total performance and each single event performance relations, and by comparing Chinese athlete and world level top athlete each single event differences, it looks for Chinese athletes' performance improving breakthrough point to correspondingly guide Chinese athlete future training. World level top men's decathlon athlete each single event is comprehensive developing, his each single event performance is relative stable, each body quality develops in all-around way, each single event also arrives at relative high level. And Chinese athlete each type sport event performance is not stable, training level cannot arrive at world level athlete level, he has larger development space. Chinese athlete and world level athlete difference is comprehensive, especially for jumping type event and throwing event; it suggests that Chinese athlete during comprehensive training process should strengthen strength training, and strive to improve throwing type event competitive level. Meanwhile, strengthen stronger technical jumping sport event training and achieve overall improvements. World level top

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athlete has his own strong sport events, it suggests that Chinese athlete according to his physical quality features, comprehensive takes training and improving each single event performances, meanwhile develops his dominant sport event, which implements advantageous for future competition.

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