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## Difference analysis of physical quality affects flop performance based on GST and logistic

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### ABSTRACT

Since flop technique emerged, through constant improvement and innovation, the flop technique becomes more and more important in high jump competition. In flop technique, curved run-up and take-off are the most important parts, especially for final two steps run-up and take-off perfect joined that plays an important role in improving performance. Through researching motion skills, analyzing take-off instant state changes, it proves up what is the key to affect high jump performance, in the hope of getting higher results. To explore high jumpers high jump performance and physical qualities relationships, it adopts grey system theory grey relational degree and blockage growth model to analyze, finds out connections between the two, from which standing triple jump, run-up hands height touch, 4-6 steps run-up jump have significant influences on performance, then further define which indicator has bigger influence on high jump performance and based on that it carries out more targeted training in high jumpers daily training. © 2014 Trade Science Inc. - INDIA

### KEYWORDS

Flop;  
Logistic model;  
Grey system theory (GST);  
Influence factor.

### INTRODUCTION

High jump is one of jump events in athletics; it can be subdivided into run-up, take-off, clear the bar, land and other motions. Athlete performance is judged on his final cleared heights. Straddle, shear mode, roll, prostrate and flop are main bar-over ways in high jump technique. Due to different techniques existing, athletes' competition fulfillment process is not the same. Athletes let themselves have certain speed through running-up; it can increase reaction force when taking-off and stimulate nerves to quicken motions. Among them, flop run-up route is arc, which lets it have advantages of long distance and fast speed. While other postures are gen-

erally straight-line running-up. Earliest high jump technique is straddle, British athlete just created earliest record by using straddle, he jumped over 1.67m. After that, athlete Brooks in the same country also used the method jumping over 1.89m in 1867. While American athlete Sweeney jumped over 1.97m with different high jump technique in 1895, after that another high jump technique appeared. First formal high jump world record affirmed by international association of athletics federation is American athlete Holling jumped 2m mark in 1912.

Since 1950s, mass perspectives have started to focus on human body potential, so it starts to form into more perfect training system. Typical of them is former

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Soviet Union athlete Brummell; he has set world record successively for six times, final performance is 2.28m. While for flog records, it was American athlete Fosbury who jumped over 2.24m cross bar in 1968 and achieved such session Olympic Games men high jump gold medal, after that, such high jump way is hugely popular. Finally in 1973, American athlete Stones jumped 2.30m with flogs technique, whose performance first broke through previous records held by prostrate. At present, men and women high jump world record are respectively 2.45m and 2.09m, which respectively set by Cuba athlete Sotomayor and Bulgarian Kostadinova adopted flog<sup>[1]</sup>. Flog high jump technique is most popular at present, so how to improve athlete performance by adopting flog high jump technique becomes a focus.

This research melts computer technology and mathematical modeling thoughts into sports training, make quantization of more data to analyze sports athletes advantages and disadvantages in events, so that help them to carry out more reasonable, targeted sports training.

### FLOG HIGH JUMP TECHNIQUE BIOMECHANICAL ANALYSIS

#### Technology as well as advantages and disadvantages

At present, in mostly adopted high jump techniques, it is mainly with flog technique; for flog technique, it can roughly divided into following three stages:

**Running-up stage:** It means that starting from running-up, by running some distance (nearly 8 to 12 steps), control rhythm making final step enter into taking-off point such stage.

**Taking-off stage:** It refers that athlete in taking-off moment, controls gravity center shifting in soaring process by controlling limbs swinging. Taking-off stage technique is especially important to high jump performance.

**Clearing the bar and landing stages:** It refers to athlete after soaring, adopts correct technical motion crossing over the bar and safely landing technical stages.

Flog technical advantages:(1) The way is relative simple, performance soon get remarkable improvement once used it.(2) It can better combine with received dynamic energy when running-up.(3) Due to adopt J

type curved running-up, human body runs along curve, because of centripetal force effects, body will lean towards circle center direction that can increase accelerate distance when taking-off, let taking-off more powerful.(4) Adopt flog to clear the bar, when clearing the bar, human body back turns downwards, human body successively clears the bar in bridge type, which can better make use of soaring height.

#### High jump performance basic influence factors analysis

High jump performance basic influence factors include  $H_1, H_2, H_3$ .  $H_1$  refers to figure and body postures when taking-off.  $H_2$  Refers to vertical speed when taking-off, the speed including landing moment vertical speed and vertical impulse (Taking-off moment vertical force and taking-off time).  $H_3$  Refers to body postures and bar-over motions when arrives at top point. From which, running-up is one of the most important high jump techniques, for flog running-up stage, especially important is running-up last two steps.

Due to flog is athlete clearing the bar with back towards the cross-bar, but people can't run-up with back towards cross-bar, so it adopts curve running-up to turn body direction. In the earlier stage of J type running-up, athlete can get relative higher speed and momentum, when it gets close to take-off moment, utilizes curve running-up to let body turn so that back towards cross-bar.

Running-up radian sizes and speed when entering the curve decide athlete body downward inclined angle in the moment of running-up last two steps. When running-up route radian becomes bigger, entering into running-up curve speed gets slower, human body downward inclined angle will be smaller. When running-up route radian becomes smaller, entering into running-up curve speed gets faster, human body downward inclined angle will be bigger. When entering into running-up curve speed getting faster, generated centrifugal force will be bigger, in this way, rotational dynamic energy generated through taking-off will be bigger.

#### Analysis of taking-off legs grounding instantaneous state

In human body soaring process, gravity center ini-

tial speed V is one of important factors decide high jump performance, it can be known from speed compounding that V is joined speed of taking-off moment horizontal speed and vertical speed. Running-up speed provides horizontal speed for V. In taking-off moment, horizontal speed part transforms into taking-off vertical speed. In the transformation process, it will lose partial horizontal speed. Therefore, improve taking-off moment horizontal speed will be greatly helpful for improving high jump performance. The faster running-up speed is, the bigger human body momentum is, in taking-off process especially in buffer stage human body generated action force to ground will be bigger, received upwards accelerated speed will be bigger accordingly. When taking-off legs buffer, taking-off legs are forced to bend, extensor is forced to extend, on one hand, it stores lots of elastic potential energy, on the other hand, it will stimulate nervous system generating myotatic reflex, meanwhile extends muscle initial length, which creates good muscle exert condition for pedaling and stretching motions and will surely produce bigger pedaling and stretching strength and speed.

Therefore in high jump process, run-up speed is

decisive. Speed up running-up speed can get bigger horizontal speed, corresponding stimulate athlete taking-off moment upwards accelerated speed will be bigger, upwards soaring effects will be better.

### HIGH JUMP PERFORMANCE AND EACH PHYSICAL QUALITY GREY RELATIONAL DEGREE ANALYSIS

At first establish high jumpers' high jump performance and each physical quality indicator system, as TABLE 1.

Make 0-1 standardization of TABLE 1 data according to formula (1), it gets TABLE 2:

$$f(x(k)) = \frac{x(k) - \min x}{\max X - \min X} \tag{1}$$

For each physical quality indicator and high jump performance relationships, it can adopt grey relational degree analysis; further make clear their mutual relationships, as formula (2).

$$\xi_i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|} \tag{2}$$

TABLE 1 : 15 world men high jumpers high jump performance and each physical quality indicator

High jump Performance (m)	30m running in marching (s)	100 m(s)	Standing triple jump (m)	Running-up hands height touch (m)	4-6 steps running-up high jump (m)	Back throw shot (m)	Snatch (kg)	Squat barbell (kg)	Barbell squat coefficient
2.40	2.6	10.7	10.10	1.25	2.25	16.00	135	200	2.55
2.39	2.7	10.8	10.05	1.24	2.24	15.90	132.5	197.5	2.52
2.38	2.7	10.8	10.00	1.23	2.23	15.80	132.5	195	2.50
2.37	2.8	10.8	9.95	1.22	2.22	15.70	130	192.5	2.47
2.36	2.8	10.8	9.90	1.21	2.21	15.60	130	190	2.45
2.35	2.8	10.8	9.85	1.20	2.20	15.50	127.5	187.5	2.42
2.34	2.9	10.9	9.80	1.19	2.20	15.40	127.5	185	2.39
2.33	2.9	10.9	9.75	1.19	2.19	15.30	127.5	182.5	2.37
2.32	2.9	10.9	9.70	1.18	2.18	15.20	125	180	2.34
2.31	2.9	10.9	9.65	1.18	2.18	15.00	125	177.5	2.32
2.30	3.0	10.9	9.60	1.17	2.17	14.80	122.5	175	2.29
2.29	3.0	10.9	9.55	1.17	2.16	14.60	120	172.5	2.26
2.28	3.0	11.0	9.50	1.16	2.16	14.40	120	170	2.24
2.27	3.0	11.0	9.45	1.16	2.15	14.20	117.5	170	2.20
2.26	3.0	11.0	9.40	1.15	2.14	14.00	115	167.5	2.18

TABLE 2 : Data after original data standardization

High jump performance (m)	30m running in marching (s)	100 m(s)	Standing triple jump (m)	Running-up hands height touch (m)	4-6 steps running-up high jump (m)	Back throw shot (m)	Snatch (kg)	Squat barbell (kg)	Barbell squat coefficient
1.00	0	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.93	0.25	0.33	0.93	0.90	0.91	0.95	0.88	0.92	0.92
0.86	0.25	0.33	0.86	0.80	0.82	0.90	0.88	0.85	0.86
0.79	0.50	0.33	0.79	0.70	0.73	0.85	0.75	0.77	0.78
0.71	0.50	0.33	0.71	0.60	0.64	0.80	0.75	0.69	0.73
0.64	0.50	0.33	0.64	0.50	0.55	0.75	0.63	0.62	0.65
0.57	0.75	0.67	0.57	0.40	0.55	0.70	0.63	0.54	0.57
0.50	0.75	0.67	0.50	0.40	0.45	0.65	0.63	0.46	0.51
0.43	0.75	0.67	0.43	0.30	0.36	0.60	0.50	0.38	0.43
0.36	0.75	0.67	0.36	0.30	0.36	0.50	0.50	0.31	0.38
0.29	1.00	0.67	0.29	0.20	0.27	0.40	0.38	0.23	0.30
0.21	1.00	0.67	0.21	0.20	0.18	0.30	0.25	0.15	0.22
0.14	1.00	1.00	0.14	0.10	0.18	0.20	0.25	0.08	0.16
0.07	1.00	1.00	0.07	0.10	0.09	0.10	0.13	0.08	0.05
0	1.00	1.00	0	0	0	0	0	0	0

Among them,  $x_0$  is reference sequence;  $x_i$  is each factor sequence, from which all numbers of sequence elements are k pieces;  $\rho \in [0,1]$  is resolution coefficient that the bigger  $\rho$  is, the bigger resolution ratio will be, the smaller  $\rho$  is, the smaller resolution ratio will be;  $\min_i \min_k |x_0(k) - x_i(k)|$  and  $\rho \max_i \max_k |x_0(k) - x_i(k)|$  are fixed numbers, which are respectively two-level minimum difference, two-level maximum difference.

Relational degree computation formula is formula (3):

$$r_i = \frac{1}{n} \sum_{k=1}^n \xi_i(k) \tag{3}$$

Among them,  $n$  is maximum value of  $k$ .  $r_i$  is sequence and reference sequence relational degree. By MATLAB software calculating, it gets TABLE 3:

From TABLE 3, it is clear that standing triple jump,

running-up hands height touch, 4 to 6 steps running-up high jump these three items are more correlated to athlete high jump performance.

**HIGH JUMP PERFORMANCE INFLUENCE FACTORS BLOCKAGE GROWTH MODEL**

Assume that athlete high jump performance growth rate  $r$  is original high jump performance  $x$  linear decreasing function that is with high jump performance increasing, high jump performance increasing speed will gradually slow down. Adopt blockage growth model formula (4):

$$r(x) = r_0 - sx \tag{4}$$

Athlete high jump performance will finally arrive at saturation, and tends to a constant, when; growth rate is 0, as formula (5):

$$r_0 - sx_m = 0 \tag{5}$$

From above expressions (4) (5), it can get formula

TABLE 3 : MATLAB software calculated relational degree value

$r_1$	$r_2$	$r_3$	$r_4$	$r_5$	$r_6$	$r_7$	$r_8$	$r_9$
0.433	0.500	0.578	0.667	0.580	0.473	0.544	0.472	0.504

TABLE 4 : Previous olympic games men high jump champions' performance

Session	1	2	3	4	5	7	8	9	10	11
Performance	1.81	1.90	1.80	1.90	1.93	1.93	1.98	1.94	1.97	2.03
Session	14	15	16	17	18	19	20	21	22	23
Performance	1.98	2.04	2.12	2.16	2.18	2.24	2.23	2.25	2.36	2.35
Session	24	25	26	27	28	29				
Performance	2.38	2.34	2.39	2.35	2.36	2.36				

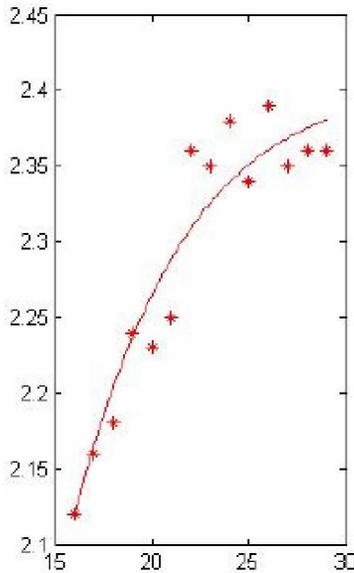


Figure 1 : Previous high jump performance fitting figure

(6):

$$r(x) = r_0 \left( 1 - \frac{x}{x_m} \right) \tag{6}$$

Input above formula (6) into exponential growth model equation, and make use of initial condition  $x(t_0) = x_0$ , it can get formula (7):

$$\begin{cases} \frac{dx}{dt} = r_0 \left( 1 - \frac{x}{x_m} \right) x \\ x(t_0) = x_0 \end{cases} \tag{7}$$

It solves formula (8):

$$x(t) = \frac{x_m}{1 + \left( \frac{x_m}{t_0} - 1 \right) e^{-r(t-x_0)}} \tag{8}$$

Below carries out analysis of previous Olympic Games men high jump champions' performance, original performance refers to TABLE 4.

Make use of initial condition  $x(16) = 2.12$ , it can get formula (9):

$$\begin{cases} \frac{dx}{dt} = r_0 \left( 1 - \frac{x}{x_m} \right) x \\ x(16) = 2.12 \end{cases} \tag{9}$$

Solve formula (9), it can get formula (10):

$$x(t) = \frac{x_{m1}}{1 + \left( \frac{x_{m1}}{2.12} - 1 \right) e^{-r_1(t-16)}} \tag{10}$$

TABLE 5 : Men flog world records progress table since 1980(m)

Time	1980	1983	1983	1984	1985	1985	1987	1988	1989	1993
Athlete	Gerd Wessing	Zhu Hua-Jian	Zhu Hua-Jian	Zhu Hua-Jian	Povarnitsyn	Paklin	Sjoberg	Sotomayor	Sotomayor	Sotomayor
Nationality	Federal Germany	China	China	China	Soviet Union	Soviet Union	Sweden	Cuba	Cuba	Cuba
Performance (m)	2.36	2.37	2.38	2.39	2.40	2.41	2.42	2.43	2.44	2.45

By MATLAB calculating, it gets  $x_m = 2.4069$ , and makes fitting of each session high jump performance as Figure 1.

From TABLE 5 data, we can know that 20 years ago Cuba player Sotomayer one jumping 2.45m by far that no one can breakthrough it, it seems that people has already tacitly approved his record as human race high jump extreme. Thus, adopt blockage growth model

to predict high jump performance is reasonable.

### CONCLUSIONS

Through research, it is clear that international men each quality indicator mainly related to triple jump, running-up height touch (net height), running-up 4to 6 steps high jump, back throw shot, squat barbell, barbell squat

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coefficient. China men each quality indicator mainly related to running-up height touch, which correlations with high jump, standing long jump, on spot vertical jump, squat barbell, on spot barbell, 100m, 30m is relative not significant.

From grey correlation, it is known that high jump performance and running-up height touch, 4 to 6 steps running-up high jump have larger correlations, their similarity is in running-up; and by consulting athletics history, it is clear that China men high jump in 1982 to 1984 exhibited higher levels, at that time famous high jump coach Hu Hong-Fei changed traditional training mode, who insisted that center on speed, striving to get equilibrium with technique training guiding thoughts, by many years' training, it let Zhu Jian-Hua jumped 2.33m in 1982 and so became world rank first in that year. And he respectively broke through world records with 2.37m, 2.38m and 2.39m performance for three times during 1983 to 1984. Due to Zhu Jian-Hua glorious performance, Soviet Union experts therefore make deeply research on Zhu Jian-Hua technique. Then it generated Soviet Union Povarnitsyn and Paklin respectively got 2.40m, 2.41m performance in 1985 Japan Kobe held world university students sports meeting, the performance broke through Zhu Jian-Hua set world record. Therefore, Soviet Union high jump coaches got following conclusions "The jumping method focus on speed is powerful".

So, in high jumpers' daily training, it should strengthen high jumpers short distance fast running training and J type curve running-up training as well as running-up and taking-off joined training, by improving curve entering speed, it further increases taking-off moment possessed momentum, so that improve high jump performance.

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