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Javelin throwing mechanical parameters correlation research and application based on dynamical model

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ABSTRACT

According to oblique projectile movement principle, assume initial speed is 25m/s, throwing height is 1.8m, under different throwing, use computer simulating javelin movement trajectory, apply comparative analysis, it gets that under different projection angles, the ranges are also different; in case projection angle is 45°, it can get maximum range of 68m. By kinematical analysis of javelin throwers' right hand throwing cross step technique and final exertion technique, it is clear that only human body upper and lower limbs, left and right side each organ coordinately exert the strength can perfect javelin throwing technique. By analyzing athletes each indicator, it gets that during javelin throwing process the cross step phase, left leg pedaling and stretching opportunity should be proper and cannot let left leg fly so high, while in final exertion whipping phase, it should master right leg pedaling and stretching opportunity, pay attention to javelin release angle and oblique angle and improve javelin throwing vertical axis exertion effects.

KEYWORDS

Oblique projectile;
Comparative analysis;
Grey prediction;
Dynamical model.

INTRODUCTION

Athletics or it calls track and field, is the general terms of track event, field event and all-round competition. Jumping, throwing events that their performances are calculated by height and distance length are called as "Field events"; Walking and running events that performances calculated by time are called as "Track events". In athletics, every sport event and mechanics are closely connected, the paper establishes mathematical model on javelin, makes mechanical analysis of it,

It gets conclusion that after all, sport performance achievement is up to athletes themselves qualities.

In recent years, though China has emerged Zhang Lian-Biao, Li Rong-Xiang, Chen Qi and others a goup of excellent men javelin throwers, they still keep greater paces with Czech Republic player Zelezny created 94.48m world record and Japanese player Mizoguchi Kazuhiro created 87.60m Asian record, which requires us based on reality finding out our country javelin throwers existing problems, trying to shorten gap with Asian or event world athletes as much as possible. A series of researches show that our country athletes exactly exist throwing arms exertion in advance and unreasonable exertion as well other problems. After all, our country javelin throwers, before "full bow" forming, they haven't made "delay" javelin and arms motions, so that it will appear exertion too early and exer-

tion order incorrect phenomenon.

Based on above problems, the paper mainly utilizes computer simulation under initial speeds are the same such circumstance, in which case release angle can arrive at furthest distance, finally establishes grey prediction model to predict future javelin performance trends. And then it can more scientific and effective guide javelin throwers training to provide theoretical support for the field multidirectional scientific researching, and finally makes reasonable suggestions.

PROBLEMS HYPOTHESIS

(1) Assume air resistance is zero (or exclude air resistance influence);
(2) Javelin oblique angle and throwing angle are the same;
(3) Assume athletes have no special diseases or fatal injury and so on, physical qualities are normal.

MODEL ESTABLISHMENT AND SOLUTION

Mechanical model

According to mechanical principle, all javelins, shot and hammer takes oblique projectile movements. Oblique projectile movement can be orthogonal decomposed into constant linear movement along horizontal direction and vertical upcast movement along vertical direction. Object throwing direction and axis positive direction included angle is called as projection angle that uses θ to express. As Figure 1 show, oblique projectile movement object in horizontal direction, it makes constant linear movement at horizontal initial speed; and in vertical direction, it makes vertical upcast movement at initial speed of v_y. Oblique projectile movement curve is a symmetrical curve.

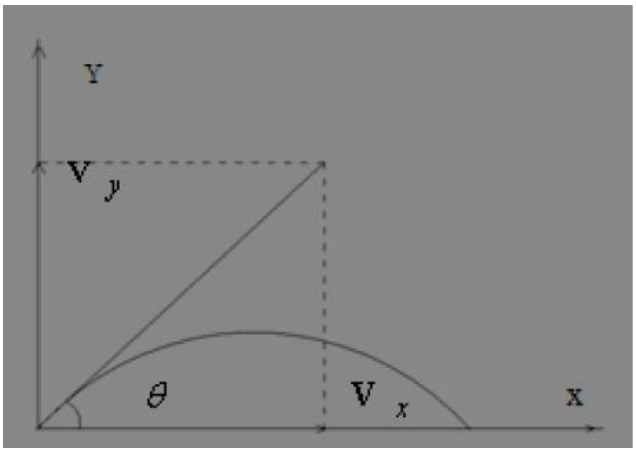

Figure 1 : Oblique projectile movement chart

Mathematical analysis is as following:

$$v_x = v_0 \cos\theta$$

$$v_y = v_0 \sin\theta - gt$$

$$x = v_0 \cos\theta * t$$

$$y = v_0 \sin\theta * t - gt^2 / 2$$

$$t = 2v_0 \sin\theta / g$$

Among them v_x is horizontal initial speed v_0 is projection speed, v_y is vertical initial speed θ is projection angle x is horizontal range, y is highest range. Object in time t total displacement is:

$$r = \sqrt{x^2 + y^2} = \sqrt{(v_0 \cos\theta \cdot t)^2 + (v_0 \sin\theta \cdot t - gt^2/2)^2}$$

It can be found from analysis that only when $v_y = 0$, javelin arrives at top point, spend time $t = v_0 \sin\theta / g$; Little ball free falling from top point required time is the same as that rising to top point. Therefore javelin flying time is: $t = 2v_0 \sin\theta / g$.

As Figure 2 show, within certain angles range, javelin distance is the furthest, and javelin performance is

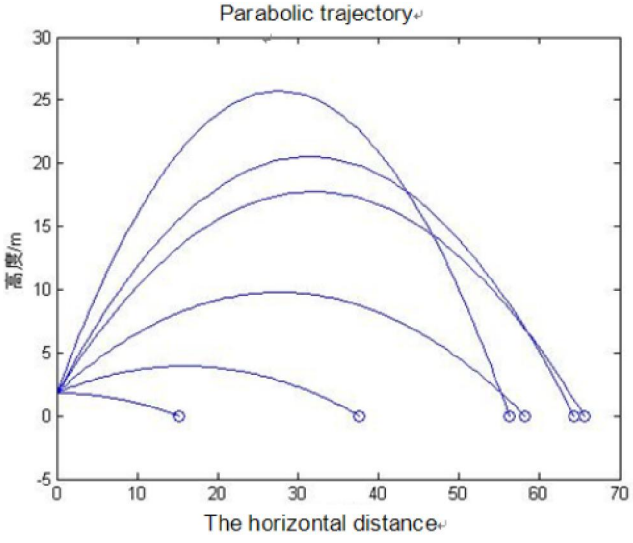

Figure 2 : Parabolic trajectory chart

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also up to javelin release speed, in some competitions, if competitors release speeds are equal, then throwing angle importance can be shown off. And, javelin is streamline apparatus, it has better sliding ability, therefore javelin movement except suffers oblique projectile movement influence, it will also suffer fluid influence.

Javelin has an oblique angle to airflow, the paper divides air effects compound force (F) into vertical direction component force and horizontal direction component force (as Figure 3). Horizontal component force

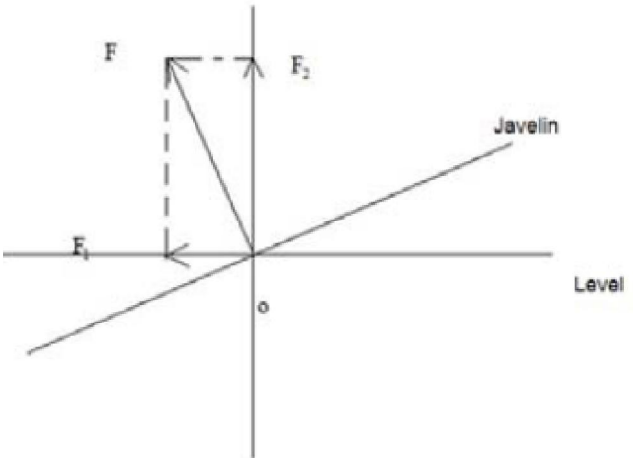

Figure 3 : Javelin projection position chart

(F_1)is forward resistance that hinders javelin forward flight, it requires consuming energy to overcome it, vertical component force (F_2)due to its function can let javelin rise, which extends javelin air sliding time, and helpful for javelin performance improving, according to lots of experiences and valid data, it can get most proper attacking angle is 8.2° .

Make evaluation on athletes' each parameter

To find out which qualities that javelin throwers should possess, it collects Chinese partial excellent men javelin throwers exercises data so that it can make kinematic analysis of throwing last two steps and final exertion techniques, as TABLE 1 show.

According to TABLE 1 data, draw out javelin trend chart, as Figure 4 show.

According to Figure 4 showed broken line, we classify the technical process into following several stages and time phases to make research.

Stage classification: Cross step stage(from throwing step the second step left foot landing to cross step

TABLE 1 : 8 research objects javelin release parameters status

Name	Release initial speed(m/s)	Release angle (°)	Release height(m)	Javelin oblique angle(°)	Attack angle(°)
1	27.43	36	2.25	39	3
2	27	40	2.21	40	0
3	26.57	40	2.07	37	-3
4	26.23	39	2.03	43	4
5	25.17	36	7.83	41	5
6	24.92	42	1.96	35	-7
7	24.83	36	1.76	34	-2
8	23.07	42	1.83	36	-6
x	25.65	38.88	1.99	38.13	-0.75

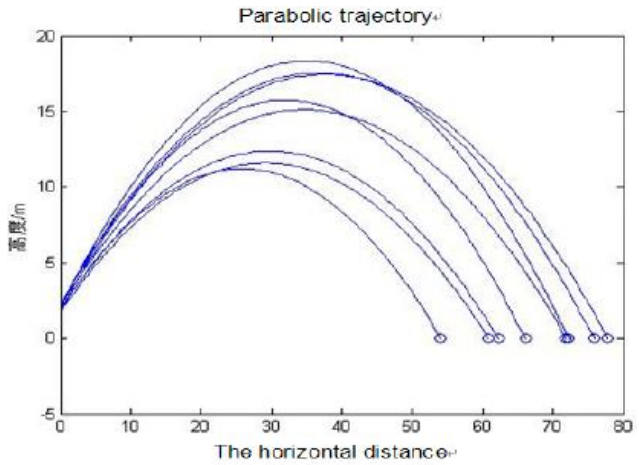

Figure 4 : 8 athletes javelin trend chart

right foot grounding instant); right foot single supporting stage (from cross step right foot grounding instant to left foot grounding instant); two legs supporting stage (left foot grounding instant to javelin releasing).

Time phases classification:(1) Start cross step in left foot grounding instant;(2)left foot pedaling out of ground instant;(3) cross step ending right foot grounding instant : (4) throwing step final step left foot grounding instant;(5) "full bow" instant; (6) javelin releasing instant.

Cross step technical analysis

In javelin throwing, cross step is used for make preparation for javelin throwing and connecting final exertion motion, the paper assumes that athletes use right hand throwing, average cross step speed of some famous javelin throwers is 0.78m/s , generally speaking, it requires athletes reduce gravity center horizontal

TABLE 2 : 8 athletes throwing step final steps body gravity center horizontal speed (m/s)

Name	A	C	D	F	A-C speed loss rate (%)	C-D speed loss rate(%)
1	8.63	6.91	5.92	2.76	19.93	14.33
2	8.07	5.36	4.34	2.62	33.58	19.03
3	8.37	6.54	5.63	2.96	21.86	13.91
4	9.55	6.27	5.43	1.77	34.35	13.4
5	7.93	7.47	7.04	1.57	5.8	5.8
6	7.25	6.12	5.26	1.79	15.59	14.05
7	5.56	4.77	3.18	1.44	14.2	12.37
8	6.48	5.93	4.21	1.31	8.49	29
x	7.73	6.17	5.13	2.03	20.18	16.86

TABLE 3 : 8 athletes throwing step final two steps hip joint speed (m/s)

Name	Right hip horizontal speed				Left hip horizontal speed			
	A	B	C	D	A	B	C	D
1	9.61	9.25	6.38	6.03	9.21	8.79	6.77	5.12
2	8.83	6.2	3.25	3.03	9.06	6.39	4.16	4.03
3	8.29	8.72	5.72	5.43	8.88	7.69	6.58	4.54
4	11.63	7.97	5.79	6.09	8.92	8.08	6.72	1.07
5	8.22	7.45	5.73	5.46	6.9	7.83	7.45	6.17
6	8.05	7.45	5.73	5.46	8.26	6.48	4.89	3.39
7	6.08	5.65	4.66	2.71	4.47	5.81	4.33	3.28
8	7.58	7.72	6.21	3.25	5.74	5.39	5.51	3.24
x	8.54	7.55	5.27	4048	7.68	6.98	5.68	3.86

Note: A In left foot grounding instant, it starts cross step; B Left foot pedaling out of ground instant; C Cross step ends, right foot grounding instant; D Throwing step final step left foot grounding instant.

TABLE 4 : 8 athletes throwing step final two steps knee joint speed (m/s)

Name	Right knee horizontal speed				Left knee horizontal speed				
	A	B	C	D	A	B	C	D	F
1	10.3	10.64	5.74	5.29	6.77	7.83	8.04	4.31	-0.89
2	11.33	7.94	9.23	4.23	7.2	6.36	5.7	2.15	-0.14
3	10.16	9.01	6.18	4.41	7.51	7.57	7.58	4.42	0.66
4	13.5	7.65	4.48	4.54	6.26	8.02	8.1	4.38	-0.18
5	6.88	8.64	5.64	3.27	7.36	7.89	8.16	5.73	-0.1
6	9.32	8.36	7.68	4.16	5.44	6.08	6.98	4.36	-0.27
7	6.3	7.19	4.45	3.03	7.54	5.43	6.45	3.14	-0.91
8	9.47	8.83	6.25	3.92	7.06	7.32	7.57	4.21	-0.13
x	9.66	8.53	6.2	4.1	6.52	7.06	7.32	4.09	-0.17

speed loss, it gets 8 athletes throwing step final two steps body gravity center horizontal speed (m/s), as TABLE 2 show.

Hip joint speed changes analysis

After cross step, hip joint is in accelerated phase, to make good preparation for "full bow" phase, generally athletes' left hip horizontal speed continues to reduce, as TABLE 3 show.

Knee joint speed changes analysis

Knee joint movement plays crucial roles in javelin throwing; well knee joint movement can keep well cross step movement, and let pedal and stretch movement arrive at standard. Sorting out data, it can get 8 athletes throwing step final two steps knee joint speed, as TABLE 4 show.

By TABLE 4 data, it is clear that left knee speed in knee bending phase is in reducing trend, under effects of left leg pedaling and stretching, right knee speed arrives at peak till falling.

Cross step's step length, time and gravity center flight height analysis

To javelin throwers, cross step should try to keep step height lower, pace flat, quick; if cross step is too small, it cannot connect with throwing motions, by sorting, it gets 8 athletes throwing step final two steps' step

TABLE 5 : 8 athletes' throwing step final two steps' step length, completion time and gravity center flight height

Name	T4 (m)	T5 (m)	T1 (s)	T2 (s)	T3 (s)	T6 (m)	T7 (°)
1	2.42	1.76	0.23	0.2	0.14	0.13	73.17
2	2.29	1.54	0.3	0.22	0.18	0.2	85.73
3	2.15	1.64	0.23	0.19	0.14	0.09	74.82
4	2.71	1.45	0.26	0.18	0.15	0.15	81.26
5	1.61	1.29	0.24	0.18	0.14	0.14	75.12
6	1.83	1.48	0.23	0.16	0.17	0.09	83.91
7	1.45	1.32	0.18	0.2	0.17	0.04	80.81
8	2.17	2.03	0.31	0.28	0.15	0.12	83.16
x	2.08	1.63	0.26	0.21	0.16	0.12	79.75

Note: T1: refers to cross step flight time; T2: cross step ends, right foot grounding instant to final step left foot grounding time; T3: left foot grounding to javelin releasing time; T4: cross step's step length;T5: final step's step length; T6: gravity center flight height; T7: left leg ground angle

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length, completion time and gravity center flight height, as TABLE 5 show.

CONCLUSIONS

The paper firstly makes mechanical analysis of javelin movement according to mechanical relations. Javelin movement belongs to oblique projectile movement, apply oblique projectile specialties to analyze javelin movement, and make evaluation on athlete each parameter, the paper selects 8 typical athletes to make analysis. Analyze from cross step technical analysis, hip joint speed changes analysis, knee joint speed changes analysis, cross step's step length, time and gravity center flight height analysis these four aspects, and get relative reasonable movement phase analyses. In cross step phase, left leg pedaling and stretching opportunity should be proper and cannot let left leg fly so high, while in final exertion whipping phase, it should master right leg pedaling and stretching opportunity, the most important point is paying attention to javelin release angle and oblique angle and improving javelin throwing vertical axis exertion effects.

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