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Shot Performance Influence Factors Correlation Degree Analysis Based on Genetic Algorithms

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Abstract: The paper first applies Newton mechanical and physical knowledge to establish shot throwing process mathematical model, calculates throwing performance is related to α,h,F,t_0,v_0 these five factors; the next, it adopts genetic algorithms to solve optimal throwing performance and these five factors best parameters, from which optimal throwing performance is 21.78m; finally it adopts grey relational degree algorithms and analyzes five influence factors' primary and secondary relation is α,h,F,t_0,v_0 , which provides scientific evidence for making scientific training plans, during training, coaches and athletes should pay attention to foster strengths and circumvent weakness, give their own advantages into full play so that can get more ideal results.

Keywords: Genetic algorithms, grey relational degree, influence factor, mathematical model.

1. INTRODUCTION

Shot is a kind of very important sports competitive event, and in some important competitions, athletes' shot throwing strength is basically the same by training, that is to say, it is always athletes' throwing skills that decide competition winning. And to improve skills, athlete should learn about shot whole process status [1]. Firstly it should carry out kinematical analysis of shot whole movement status, according to kinematical knowledge, it solves throwing performance and release angle, release speed, and release height so on multiple equation, after that it makes use of mathematical analysis to analyze influence factors in training on established model, and make clear influence factors primary and secondary relation, and guide training with scientific method [2]; in training, athletes should pay attention to foster strengths and circumvent weakness, give their own advantages into full play so that can get more ideal results [3].

2. PROBLEMS ASSUMPTION

Assume shot is regarded as a particle;

Assume throwing process ignore air resistance influence;

Assume that gliding can make superposition with throwing ;

Assume gliding phase is horizontal movement, shot generates a horizontal initial speed v_0 with human body;

Assume throwing instant, athlete acting on shot push force size is F that remains unchanged, force direction and shot release angle α are consistent [4].

Model used symbols description can refer to (Table **1**).

Table 1. Model used symbols corresponding description.

Letter	Description
v	Shot release speed
m	Shot mass
α	Release angle
h	Shot release instant height
$S1$	Distance that shot release instant goes beyond stop board
S	Shot flight distance

3. MODEL ESTABLISHMENT

3.1. Throwing Process Physical Model Establishment

By Newton mechanical and physical knowledge, it establishes model, (Fig. **1**) shows shot throwing process schematic diagram [5].

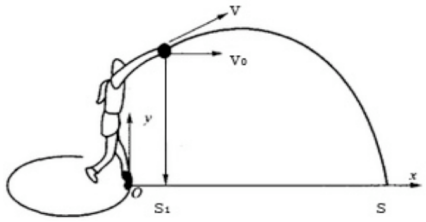

Fig. (1). Schematic diagram.

Take athlete stance as origin O, vertical direction is Y axis, connection line between shot and O point is X axis, establish rectangular coordinate system and get (Fig. **2**).

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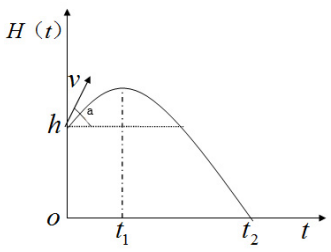

Fig. (2). Throwing rectangular coordinate system.

By Newton second law, it gets:

$$\mathrm{mx}^{''}(t) = F\cos\alpha$$

$$my^{''}(t) = F\sin\alpha - mg$$

Make integral o above formula and get:

$$x^{'}(t) = \frac{F}{m}t\cos\alpha$$

$$y^{'}(t) = \frac{F}{m}t\sin\alpha - gt$$

It is known that acting time is t_0, so shot release speed is:

$$v = \sqrt{x^{'}(t)^2 + y^{'}(t)^2}$$

$$= \sqrt{(\frac{F^2}{m^2} + g^2 - \frac{2F}{m}g\sin\alpha)\ t_0^2 + v_0^2 + \frac{2F}{m}t_0 v_0\cos\alpha}$$

Shot throwing performance is:

$$\mathrm{s} = \mathrm{s}_1 + \frac{v^2\sin 2\alpha}{2g} + \sqrt{[\frac{v^2\sin 2\alpha}{2g}]^2 + \frac{2hv^2\cos^2\alpha}{g}}$$

Due to S_1 is horizontal distance between shot release instant stop board and release point, it is up to athlete throwing technique and body condition, therefore shot practical flight distance is:

$$\mathrm{s} = \frac{v^2\sin 2\alpha}{2g} + \sqrt{[\frac{v^2\sin 2\alpha}{2g}]^2 + \frac{2hv^2\cos^2\alpha}{g}}$$

Formula describes throwing distance s and shot release instant stop board excess distance, release angle, release angle, release speed as well as release height function relations. By daily actual measurement training data, it is clear that shot release instant stop board excess distance's influence on throwing distance is weaker, so only consider when $\alpha,\mathrm{h},\mathrm{F},\mathrm{t}_0,v_0$ these five influence factors change, their influences on throwing distance s. Shot throwing distance is a complex extremum problem, and when $\alpha,\mathrm{h},\mathrm{F},\mathrm{t}_0,v_0$ these five influence factors change, their influence on throwing distance s. Shot throwing distance s is a complex extremum problem, and $\alpha,\mathrm{h},\mathrm{F},\mathrm{t}_0,v_0$ five variables simultaneous change, which almost cannot solve by analyzing method, the paper adopted genetic algorithms (GA) is by far novelty and relative common used method.

3.2. Mathematical Analysis

Genetic Algorithms, is called GA for short, is a kind of searching (optimizing) algorithms based on natural selection and genetics theory, which simulates natural life evolving mechanism, and realizes special targets optimization in artificial system. The essence of genetic algorithms is generational evolving according to theory of survival of the fittest by group searching techniques, and finally getting optimal solution or quasi optimal solution.

Genetic algorithms and traditional optimization algorithms are basically the same both in modelling thoughts and steps, only GA algorithms objective function uses compensation (fitness function) without using derivatives or other auxiliary information, therefore it is more loose by comparing with traditional algorithms and stronger in problems adaptability; and then according to concrete forming process, add it with necessary equality and inequality constraints; finally solve feasible domains' optimal solution with GA algorithms iterative process.

Genetic algorithms iteration process in calculation includes coding, selection (copy), crossover, variation and other processes. Crossover and saltatory variation maintain searching space diversities, it potentially owns environment changes adaptability; GA algorithms can simultaneously search space lots of points by evaluating, eliminating process, and can fully search therefore it can make fast global convergence. Crossover and variation ensure searching space diversity, it potentially owns environment changes adaptability.

Coding way here adopts floating number to code; initial group adopts random method to generate. Due to optimized objective is solving throwing distance maximum value, so take objective function that is throwing distance function as fitness function. Copying process uses roulette wheel method to proceed, crossover process adopts arithmetic crossover, variation process adopts uneven variation. It proceeds with following ways

$$X_1^{*} = X_1 + (1-\lambda)X_2;\ X_2^{*} = X_2 + (1-\lambda)X_1;$$

$$\Delta(t,y) = y * r(1-\frac{t}{T})^b$$

In formula, $\lambda is 0<\lambda<1$ random number, x_1,x_2 is original individual coding value, x_1^{*},x_2^{*} is new individual coding value after making cross operation. t is iterative number, T is terminate algebra, b is parameter that adjusts variation degree, and b>0.y is one individual coding value component and the component upper limit or lower limit difference, $\Delta(t,y)$ is when variation occurs, the individual coding value each component variable quantity.

In the model GA iterative calculation process, crossover probability Pc takes 013, variation probability Pm takes 011, K takes 015, population size takes 10, terminate iterative times take 1 000;Take international women's competition shot standard mass 4kg as an example, shot throwing process optimization result can refer to (Table **2**).

Table 2. Throwing process optimization process.

Name	α	h/m	F/N	t_0 / s	$v_0 / m \bullet s^{-1}$
Independent variable values range	0.00~45.00	1.80~2.10	0.00~225.0	0.00~0.24	0.00~2.00
Extremum moment independent variable values	35.73	2.10	225.00	0.24	2.00
Release speed/m	14.09				
Throwing performance/m	21.78				

Though we solve throwing model extremum problem with GA algorithms, α, h, F, t_0, v_0 these five factors influence degree on throwing distance and their primary and secondary relations are the concerns of coaches and athletes. Adopt grey relational degree analysis; make distinguish primary and secondary relations among five influence factors to throwing performance influences.

3.3. Grey Relational Degree Analysis

Grey system theory proposes concept that carries out grey relational analysis of each sub system, the intention is pursuing system each sub system (or factors) numerical relations by certain methods. In short, grey relational degree analysis significance refers that in system developing process, if two factors changing states are consistent that same change degree is higher, and then it can think that the two have larger correlations; on the contrary, then the two correlation degree is smaller. Therefore, grey relational degree analysis provides quantitative measurement for a system development changing state; it is very fit for Dynamic course analysis.

The paper averagely divides five factors optimal value range into six, as following (Table **3**) show.

Table 3. Five factors optimal value.

α / °	0	9	18	27	36	45
h / m	1.8	1.86	1.92	1.98	2.04	2.10
F / N	0	45	90	135	180	225
t_0 / s	0	0.048	0.096	0.144	0.192	0.240
$v_0 / m \bullet s^{-1}$	0	0.4	0.8	1.2	1.6	2.0

And then use London Olympic Games in 2012 and Beijing Olympic Games in 2008 women's shot performance top six to carry out relational degree analysis,

MATLAB program is as following:

```
x(1, :)=[0 9 18 27 36 45];
x(2, :)=[1.8 1.86 1.92 1.98 2.04 2.1];
x(3, :)=[0 45 90 134 180 225];
x(4, :)=[0 0.048 0.096 0.144 0.192 0.24];
x(5, :)=[0 0.4 0.8 1.2 1.6 2];
m=5;n=6;
x0=[20.56 20.28 19.86 19.50 19.20 19.08];
for i=1:n
avg(i)=0;
end
for i=1:m
for j=1:n
avg(j)=avg(j)+x(i, j);
end
end
for i=1:n
avg(i)=avg(i)/m;
end
for j=1:m
for i=1:n
x(j, i)=x(j, i)/avg(i);
end
end
for i=1:n
x0(i)=x0(i)/avg(i);
end
for j=1:m
for i=1:n
delta(j, i)=abs(x(j, i)-x0(i));
end
end
max=delta(1, 1);
for j=1:m
for i=1:n
if delta(j, i)>max
```

```
max=delta(j, i);
end
end
end
min=0;
for j=1:m
xgd(j)=0;
for i=1:n
glxs(j, i)=0.5*max/(0.5*max+delta(j, i));
xgd(j)=xgd(j)+glxs(j, i);
end
xgd(j)=xgd(j)/n;
end
xgd
```

London Olympic Games in 2012 and Beijing Olympic Games in 2008 women's shot performance (Table **4**).

Table 4. Olympic games women's shot performance.

score	SCORE					
2012	21.36	20.70	20.48	20.22	19.63	19.42
2008	20.56	20.28	19.86	19.50	19.20	19.08

Use MATLAB programs to operate correlation degree (Table **5**).

Table 5. Relational degree analysis table.

na	α / °	h/m	F/N	t_0 / s	$v_0 / m \bullet s^{-1}$
2012	0.8768	0.8717	0.8073	0.8664	0.8673
2008	0.8766	0.8706	0.7978	0.8647	0.8656

By relational degree analysis (Table **5**), it gets correlations with throwing performance successive from strong to weak is : α, h, v_0, t_0, F .

Because athlete height and arms' length are certain, it should strengthen release angle and gliding speed training at ordinary training so that can reduce training blindness and improve training effects.

CONCLUSION

By above model analysis, it can get following conclusions: in optimal release angle tolerance range, to the same athlete, release height is the most important external factor that affects throwing distance, the next is gliding speed, so it should pay attention to strengthen release height and gliding speed exercising in training.

When selecting shot throwing athletes, it should select tall and strong as well as strong power athletes, which is because when release angle, release speed are certain, the taller one, his release height is surely high, so it is helpful for increasing throwing distance. Strengthen explosive power and release speed training; it is helpful for improving throwing distance. To better utilize above conclusions as guidance, it should pay attention to following key points at ordinary throwing training: when gliding, it should be low, flat and fast: in transitional phase, with left leg low and fast arriving at stop board lower edge, push hip and make lateral movement, let shot leave release point in low and far way; final exertion phase highlights forwardness. Athlete should according to his own concrete status, define best projection angle that adapts to oneself, and it is unnecessary to excessive pursue best theoretical projection angle. Release push force size has little connections with performance merits decisiveness, so ordinary training key points should put on motions techniques mastering and explosive power improvement rather than excessively highlight athlete's absolute strength increasing.

CONFLICT OF INTEREST

The author confirms that this article content has no conflicts of interest.

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Declared none.

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