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Badminton men's singles match final racket motion and scoring rate regression analysis

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ABSTRACT

Badminton match final racket motion is very crucial to badminton match's result. Look for relations between badminton final racket motion and badminton match gains and losses are surely very important to athlete technical training. Especially for comparable players' matches, players' final racket motions will become the focus. The paper takes world top men's badminton singles players as research objects. Adopt simple linear regression model, and use SPSS software to make research on final racket motion and scoring rate relationships. Utilize least square method solution on simple linear regression equation parameters to calibrate solved model's parameters. Therefore it gets badminton final racket motion and badminton match gains and losses relationship, which has important significances in future badminton players' technical and tactics training.

KEYWORDS

Badminton;
Scoring rate;
Simple linear regression model;
Least square method.

INTRODUCTION

Modern badminton was originated from Britain. In the 80s, Chinese badminton has already reached world advanced level. With Beijing Olympic Games hosted in 2008, China has gradually been among world sports powers. Meanwhile, Chinese badminton performance is moving towards higher targets. But Chinese men's singles performance is not stable. Therefore, Chinese's men's singles still need to reinforce the internal work, and further promote tactics levels.

In badminton competitions, final racket motion plays crucial roles in match result. Final racket motions totally have twenty kinds, which motion on earth is the most beneficial one for winning the match is the key to research problem. The problem has attracted attentions of numerous experts and scholars, for example, as earlier as 1989, Lin Jian-Cheng in "Women's badminton match initiative techniques and regularly discussion"; he had ever highlighted final racket motion success rate impacts on winner ability[1]. Zhou Zhi-Hui selected five world top badminton singles players they were respectively Gade, Li Zong-Wei, Lin Dan, Park Sung-hwan, and Taufik. In final racket motions, Li Zong-Wei used smashing technical efficiency was the highest, while blocking higher used proportion were successively Gade, Li Zong-Wei, Lin Dan, while Park Sung-hwan and Taufik's driving used proportions were higher.

Made statistics of five men's singles players' final racket technique used rates, it got following result. Smashing was highest motion in used proportions, scoring rate and losing rate were 37.72% and 12.64%. Secondly was lifting used proportion, scoring rate and losing rate were 4.12% and 14.84%. Blocking used proportion was 9.31%, scoring rate and losing rate were 2.26%, 14.46%. Intercepting used proportion was basically the same as lobbing that were respectively 6.91%, 6.86%, the two scoring rate were respectively 9.83%, 6.51%. Hooking used proportion was 6.17, its scoring and losing rate were respectively 4.78%, 7.22%, and rushing, pushing, driving as well as other motions use proportions were little.

The paper on the basis of previous research results, it analyzes badminton men's singles players' performance important influence factor——final racket motion, discusses linear regression algorithm, and provides theoretical basis for it, simple linear regression model is applying linear regression into sports, it makes well evaluation on players' performance and has remarkable advantages in all aspects of sports.

MODEL ESTABLISHMENT

With China gradually moving towards sports powers, badminton is also required to be constantly rose. Due to Chinese badminton men's singles performances are not stable, and final racket motion is crucial to match (As Figure 1).

Simple linear regression model

Propose that random variable Y and variable X have some correlations, X is a variable that can be controlled and precisely observed, as age, testing moment temperature, time and pressure so on. It can randomly take X 's n pieces of values $x_1, x_2, \cdots, x_n$, X is regarded as non-random variable and common independent variable. Because Y is random, to X every

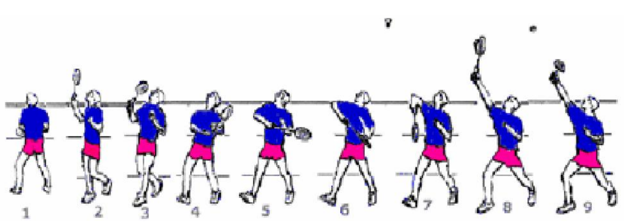

Figure 1 : The icon of badminton action

defined value, Y has its distribution, if Y exists some numerical features, then their values are defined with X extracting, it can use a group of samples (x_1, y_1), (x_2, y_2), …, (x_n, y_n) to estimate numerical features. For two variables with linear relations, due to interference of random factors, in two variables linear relations, it should include random error term ε, that simple linear regression model:

$$\mathbf{y} = \mathbf{a} + \mathbf{bx} + \boldsymbol{\varepsilon} \quad (1)$$

Among them, a is called constant term, b is called regression coefficient, ε is called random error.

Original data

The data is from Gade, Li Zong-Wei, Lin Dan, Park Sung-hwan, and Taufik five world top men badminton players. By all twenty-one important competitions' video statistics and analysis, it gets following data information TABLE 1. Data is from "World excellent badminton men's singles players' technical and tactics features research".

TABLE 1: Hitting technique scoring and losing rate status

Hitting technique	*Used percentage%*	*Scoring rate%*	*Losing rate%*
Smashing	23.43	37.72	12.64
Lifting	10.23	4.12	14.84
Blocking	9.31	2.26	14.64
Net receiving	7.6	2.66	11.33
Intercepting	6.91	9.83	4.71
High lobbing	6.86	6.51	7.12
Hooking	6.17	4.78	7.22
Rushing	4.8	7.97	2.41
Pushing	4.8	6.51	3.51
Driving	4.63	3.59	5.42
Driving clear	3.83	2.52	4.81
Net blocking	3.14	6.24	0.8
Placing	2.86	0.66	4.51
Service	2.63	2.52	2.71
Backhand dropping	0.69	0	1.2
High point placing	0.63	1.2	0.2
Killing	0.51	0.8	0.3
Backhand clearing	0.51	0	0.9
Low dropping	0.29	0	0.5
Clearing	0.11	0	0.2
Moving	0.06	0.13	0
Total	100	100	100

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Final racket motion and losing score relations

Model preliminary establishment

Number the hitting techniques, corresponding number 1-21, numbers amount is X, score is Y, use SPSS software to make simple linear regression analysis of two groups of data, it gets final racket motion and losing scores function relations, (to easy compare, we expand score result by a hundred times when calculating):

$$\mathbf{y = -0.744 + 7.674 \cdot \frac{1}{x}} \tag{2}$$

According to SPSS analysis result, it can get function image as Figure 2.

SPSS software generated mathematical model precise is not so high, it needs to choose higher precise model, each model precise is as following TABLE 2.

By above TABLE 2, it is clear that reciprocal equa-

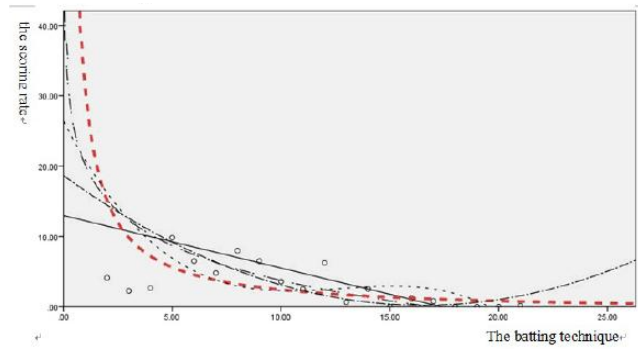

Figure 2 : Relations with batting technique and the scoring rate

TABLE 2 : Model summary and parameter estimated value

Equation	Model summary					Parameters values estimation			
	R square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	0.367	10.424	1	18	0.005	13.792	-0.848	0	0
Logarithm	0.573	24.156	1	18	0.000	21.220	-7.716	0	0
Reciprocal	0.786	66.267	1	18	0.000	-1.025	32.870	0	0
Quadratic	0.470	7.532	2	17	0.005	20.59	-2.685	0.087	0
Cubic	0.546	6.422	3	16	0.005	28.516	-6.761	0.561	-0.015
Compound[a]	0	0	0	0	0	0	0	0	0
Power[a]	0	0	0	0	0	0	0	0	0
S[a]	0	0	0	0	0	0	0	0	0
Growth[a]	0	0	0	0	0	0	0	0	0
Index[a]	0	0	0	0	0	0	0	0	0
Logistic[a]	0	0	0	0	0	0	0	0	0

tion precise is the highest, so we select reciprocal equation, and make further calibration on its parameters.

Model parameters calibration

In the following, we further define parameters a, b. In the problem, it totally has 21 groups of data $(x_1, y_1), (x_2, y_2), \cdots, (x_i, y_i)$, $i = 1,2,\cdots 21$, according to formula(1), it has:

$$\begin{cases} \mathbf{y_i = a + bx_i + \varepsilon_i} \\ \mathbf{E_{\varepsilon_i} = 0, D_{\varepsilon_i} = \sigma^2 (i = 1,2,\cdots,21)} \\ \varepsilon_i \end{cases} \tag{3}$$

By formula (2), it has $\varepsilon_i = y_i - a - bx_i$, $i = 1,2,\cdots,21$, record:

$$\mathbf{Q(a,b) = \sum_{i=1}^{21} \varepsilon_i^2 = \sum_{i=1}^{21} (y_i - a - bx_i)^2} \tag{4}$$

$a + bx_i (i = 1,2,\cdots,21)$ is regression value, $Q(a,b)$ represents samples observed value y_i and regression value's deviation status, $Q(a,b)$ gets smaller, deviation will be smaller ÿ $Q(a,b)$ Gets bigger, deviation will become bigger. To solve regression model, it should let deviation value to be the minimum one. Because $Q(a,b)$ is a and b function, a and b values should let $Q(a,b)$ to arrive at the minimum. Therefore, regarding a and b values solution problems are transformed into solving binary function $Q(a,b)$ minimum and maximum problems.

To solve $Q(a,b)$ minimum, it needs to respectively solve partial derivatives on a,b, and partial derivative is 0, it gets partial derivative equation set :

$$\begin{cases} \frac{\partial Q}{\partial a} = -2\sum_{i=1}^{21}(y_i - a - bx_i) = 0 \\ \frac{\partial Q}{\partial b} = -2\sum_{i=1}^{21}(y_i - a - bx_i)x_i = 0 \end{cases} \quad (5)$$

Sort and get:

$$\begin{cases} na + b\sum_{i=1}^{21} x_i = \sum_{i=1}^{21} y_i \\ a\sum_{i=1}^{21} x_i + b\sum_{i=1}^{21} x_i^2 = \sum_{i=1}^{21} x_i y_i \end{cases} \quad (6)$$

Formula (5) is normal equation set, solve the equation set can solve estimation of a and b :

$$\hat{b} = \frac{21\sum_{i=1}^{21} x_i y_i - \sum_{i=1}^{21} x_i \sum_{i=1}^{21} y_i}{21\sum_{i=1}^{21} x_i^2 - \left(\sum_{i=1}^{21} x_i\right)^2} = \frac{\sum_{i=1}^{21}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{21}(x_i - \bar{x})^2}$$
$$\hat{a} = \frac{1}{21}\sum_{i=1}^{21} y_i - \frac{\hat{b}}{21}\sum_{i=1}^{21} x_i = \bar{y} - \hat{b}\bar{x} \quad (7)$$

Calculate and get: $\hat{a} = -0.7466, \hat{b} = 33.2264$

Use SPSS and get function relation as:

$$y = -0.766 + 31.851 \cdot \frac{1}{x} \quad (8)$$

After parameters calibrating, function relation is:

$$y = -0.7466 + 33.2264 \cdot \frac{1}{x} \quad (9)$$

Input $x_i = 1,2,\cdots,21$ into formula (8), obtained y value and original y value comparison result is as following:

Due to backhand dropping and other motions used rates are excessive low, when verify result, it should consider case that $x_i (i = 1,2,\cdots 14)$.

By above TABLE 3, it is clear that SPSS obtained model and original data differences sum is 5.05, while model after calibration differences sum with original data is 0.30, therefore, it is clear that model after calibration is more correct.

MODEL PROMOTIONS

The model can calculate badminton final racket motion and scoring rate relations, in addition it can also be promoted to calculate badminton final racket motion and losing rate relations, use SPSS software to

TABLE 3 : SPSS model valuation, Calibration model valuation and scoring rate true value comparison

x	*y*	*SPSS Model value*	*Differences with true value*	*After calibration*	*Differences with true value*
1.00	37.72	31.09	6.64	32.48	5.24
2.00	4.12	15.16	-11.04	15.87	-11.75
3.00	2.26	9.85	-7.59	10.33	-8.07
4.00	2.66	7.20	-4.54	7.56	-4.90
5.00	9.83	5.60	4.23	5.90	3.93
6.00	6.51	4.54	1.97	4.79	1.72
7.00	4.78	3.78	1.00	4.00	0.78
8.00	7.97	3.22	4.75	3.41	4.56
9.00	6.51	2.77	3.74	2.95	3.56
10.00	3.59	2.42	1.17	2.58	1.01
11.00	2.52	2.13	0.39	2.27	0.25
12.00	6.24	1.89	4.35	2.02	4.22
13.00	0.66	1.68	-1.02	1.81	-1.15
14.00	2.52	1.51	1.01	1.63	0.89
105.00	97.89	92.84	5.05	97.59	0.30

make simple linear regression on numbers amount and losing rate two groups of data, it gets following images as Figure 3.

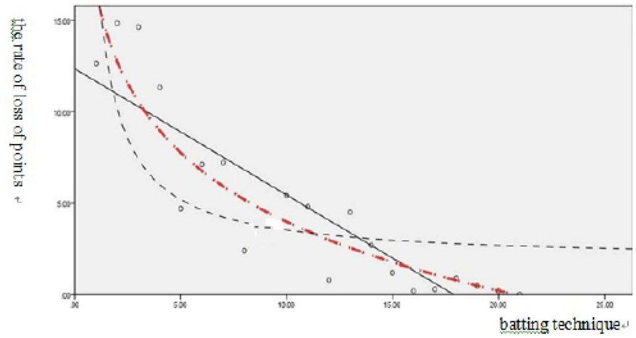

Figure 3 : Relations with batting technique and the rate of loss of points

By above Figure 3, it is clear that losing rate is in logarithm relation with numbers amount, simple linear regression equation is :

TABLE 4 : SPSS model valuation, Calibration model valuation and losing rate true value comparison

SPSS model valuation	*SPSS difference*	*After calibration valuation*	*Calibration difference*
16.527	3.887	16.75887	4.11887
13.29056	-1.54944	12.7528136	-2.08719
11.26172	-3.37828	10.5450561	-4.09494
9.822241	-1.50776	8.9786272	-2.35137
8.705693	3.995693	7.76361057	3.053611
7.793407	0.673407	6.77086969	-0.34913
7.02208	-0.19792	5.93151924	-1.28848
6.353927	3.943927	5.20444081	2.794441
5.764573	2.254573	4.56311218	1.053112
5.237379	-0.18262	3.98942417	-1.43058
4.760473	-0.04953	3.47046024	-1.33954
4.325093	3.525093	2.99668329	2.196683
3.924582	-0.58542	2.56085075	-1.94915
3.553766	0.843766	2.15733284	-0.55267
3.208545	2.008545	1.78166665	0.581667
2.885612	2.685612	1.43025441	1.230254
2.582264	2.282264	1.10015334	0.800153
2.296259	1.396259	0.78892578	-0.11107
2.025722	1.525722	0.49452976	-0.00547
1.769065	1.569065	0.21523777	0.015238
1.524932	1.524932	-0.0504247	-0.05042
	24.66489		0.234014

$$\mathbf{y = 16.527 - 5.445 \ln x} \quad \mathbf{(10)}$$

Due to software calculation error is relative bigger, therefore, use least square method to calibrate parameters a, b, a, b calibration values are

$$\hat{a} = 16.759, \hat{b} = -5.004$$

Therefore after calibration, the model is:

$$\mathbf{y = 16.759 - 5.004 \ln x} \quad \mathbf{(11)}$$

Respectively compare before and after calibration values with original value, difference result is as following TABLE 4.

By above TABLE 4, it is clear that after calibration, error is far smaller than that before calibration. Therefore losing rate and final racket motion simple linear regression model is:

$$\mathbf{y = 16.759 - 5.004 \ln x} \quad \mathbf{(12)}$$

CONCLUSION

Simple linear regression analysis is a mathematical tool to research on variables correlations; it can help us to use a variable value to estimate another variable value. The model application fields are very wide, such as talents demand problem, public security and information analysis problem, engineering technological problem as well as other aspects analysis problems.

The paper applies simple linear regression analysis into badminton field, and use least square method to calibrate parameters, the obtained model precise is high, analyticity is strong. By the paper established model, it is clear that scoring rate and badminton player final racket motion serial number are in inverse proportion. It is worth noting that the model analysis is carrying on in case two badminton players with comparable strength. Thereupon, in future badminton training process, it should adjust players' training ways in the hope of achieving more ideal results.

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