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The relational model of athlete's physical fitness indicators and jump performance

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ABSTRACT

In this paper, through fitting, logistic model (retardant growth model), multiple linear regression models, nonlinear regression models, it conducts analysis and prediction on high jump using computer software, obtains the corresponding function, and according to the function predicts the achievements for the next Olympic. Study found that due to human body function and other factors, the men's ultimate achievement will reach 2.4024 m, and women will reach 2.1173 m. We establish the scatter diagram of the domestic elite male athlete's various physical fitness indicators and high jump performance, and finds that it does not meet the linear relationship. Thus we use nonlinear regression models to analyze the domestic men jumper's physical fitness, wherein we also use the stepwise regression model. From the stepwise regression figure, we can clearly see correlation between the high jump scores and the run-up reaching height is very strong, while the correlation with other factors is weak.

KEYWORDS

Logistic model;
Simulation;
Nonlinear multiple regression;
Jump performance.

INTRODUCTION

With the development of science and technology and the continuous improvement of competitive sports standard, the applied research of "Mathematical Model" in the sports field is more widely. Through the establishment of mathematical model, precision analysis can provide a scientific basis for trainings athletes. Many high-level sports teams are quite visionary, through the collection and analysis on athletes' physical, technical, psychological and athletic ability level indicators, training methods, training load, training volume and other information, for supporting training and decision-making, and it is highly effective.

This article blends the computer technology and mathematical modeling ideas into physical training, quantizes more data to analyze the advantages and disadvantages of athletes to help them carry out a more rational and more targeted sports training.

ANALYSIS AND MODELING TO SOLVE PROBLEMS

Performance prediction model

Retardant growth model assumes

We assume that the athlete's jump performance growth rate r is a linear decreasing function of jump

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original score x, that is, with the increasing of the high jump performance, the high jump performance growth rate will gradually decline:

$$r(x) = r_0 - sx \quad (1)$$

Athlete's high performance athletes will eventually reach saturation, and tends to a constant x_m, when $x = x_m$ the growth rate is of 0:

$$r_0 - sx_m = 0 \quad (2)$$

From the above equation we can obtain:

$$r(x) = r_0\left(1 - \frac{x}{x_m}\right) \quad (3)$$

Substituting the above formula (3) into equation exponential growth model, and using the initial conditions $x(t0) = x0$ we can obtain:

$$\begin{cases} \dfrac{dx}{dt} = r_0\left(1 - \dfrac{x}{x_m}\right)x \\ x(t0) = x0 \end{cases} \quad (4)$$

We have solution of formula (5):

$$x(t) = \frac{x_m}{1 + \left(\dfrac{x_m}{t0} - 1\right)e^{-r(t-x0)}} \quad (5)$$

Symbol definition and description

r, The growth rate of athletes' jump performance

x, The original score of jump

x_m, Limitation of jump performance

Modeling and solving

TABLE 1 : The champion scores of men's and women's high jump in each session of Olympic Games

Sessions	1	2	3	4	5	7	8	9	10	11
Years	1896	1900	1904	1908	1912	1920	1924	1928	1932	1936
male(m)	1.81	1.90	1.80	1.90	1.93	1.93	1.98	1.94	1.97	2.03
female(m)								1.59	1.657	1.60
Sessions	14	15	16	17	18	19	20	21	22	23
Years	1948	1952	1956	1960	1964	1968	1972	1976	1980	1984
male(m)	1.98	2.04	2.12	2.16	2.18	2.24	2.23	2.25	2.36	2.35
female(m)	1.68	1.67	1.76	1.85	1.90	1.82	1.92	1.93	1.97	2.02
Sessions	**24**	**25**	**26**	**27**	**28**	**29**	**30**			
Year	1988	1992	1996	2000	2004	2008	2012			
male(m)	2.38	2.34	2.39	2.35	2.36	2.36	2.38			
female(m)	2.03	2.02	2.05	2.01	2.06	2.05	2.05			

The prediction model of men's performance

Using the initial conditions $x(14) = 1.98$ formula (6) can be obtained:

$$\begin{cases} \dfrac{dx}{dt} = r_0\left(1 - \dfrac{x}{x_m}\right)x \\ x(14) = 1.98 \end{cases} \quad (6)$$

We have solution of formula (7):

$$x(t) = \frac{x_m 1}{1 + \left(\dfrac{x_m 1}{1.98} - 1\right)e^{-r1(t-14)}} \quad (7)$$

Similarly, for women, using the initial conditions $x(14) = 1.68$ formula (8) can be obtained:

$$\begin{cases} \dfrac{dx}{dt} = r_0\left(1 - \dfrac{x}{x_m}\right)x \\ x(14) = 1.68 \end{cases} \quad (8)$$

We have solution of formula (9):

$$x(t) = \frac{x_m 2}{1 + \left(\dfrac{x_m 2}{1.68} - 1\right)e^{-r2(t-14)}} \quad (9)$$

We can use the existing data fitting and obtain the solution : $x_m 1 = 2.4024$, $r1 = 0.20934$; $x_m 2 = 2.1173$, $r2 = 0.15309$. We can predict the

champion scores for male and female high jump in the31 Olympic Games in Rio de Janeiro respectively are 2.3845,2.0707.

Figure 1 below shows a growth curve of championship results for both genders:

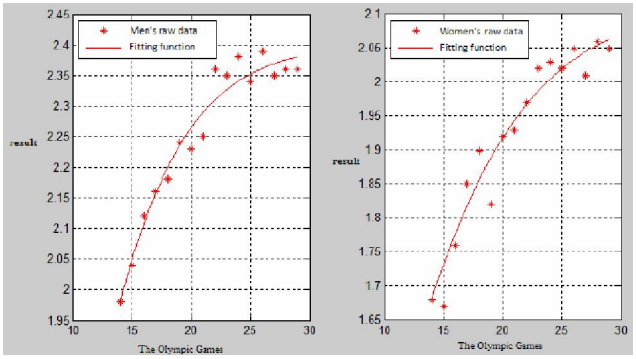

Figure 1 : The performance growth curve of male and female champions

The important factor affecting men's high jump performance

The important factor affecting international men's high jump performance

(1)Stepwise regression

According to the data given in TABLE 2, we analyze and obtain the relevance of physical fitness indicators affecting high jump scores and high jump performance. Draw scatter diagrams 2-9 of Xi (i = 1, 2, 3, 8) and Y, and determine the linear correlation of X and Y. From Figure 2-9 we know that X1, X8, namely the scores of road run 30m, 100m run have no correlation with jump scores Y, at least the relevance is not strong as other factors with the high jump score; so when fitting the regression equation the scores of road run 30m, 100m run will not be considered. The following is the scatter diagram and residual analysis diagram of the top 15 international men's physical fitness indicators and high jump scores.

We obtain the regression equation (10):

y^=0.38+0.19999*x2 **(10)**

(2)Generate random numbers for model checking

The calculation of high jumper' physical indicators are consistent with uniform random distribution, and we can use a random number generation method to detect the multiple regression equation that we get.

Random number generation method: Firstly, use the rand function to generate a set of 0-1 evenly distributed random number R, and to generate a uniform random number in the (N, M), Y = N + R * (MN), to produce.

The use of random numbers generation method:

TABLE 2 : Various quality indicators of the top 15 international male high jumpers

No.	High Jump Performance m Y	30 m road run X1	Triple Long Jump m X2	Run-up reaching height (clear height) m X3	Run-up 4-6 steps high jump m X4	Backward throwing shot m X5	Barbell deep squat kg X6	Barbell half squat coefficient X7	100 m s X8
1	2.4	2.6	10.1	1.25	2.25	16	200	2.55	10.7
2	2.31	2.9	9.65	1.18	2.18	15	177.5	2.32	10.9
3	2.39	2.7	10.05	1.24	2.24	15.9	197.5	2.52	10.8
4	2.33	2.9	9.75	1.19	2.19	15.3	182.5	2.37	10.9
5	2.37	2.8	9.95	1.22	2.22	15.7	192.5	2.47	10.8
6	2.27	3	9.45	1.16	2.15	14.2	170	2.2	11
7	2.35	2.8	9.85	1.2	2.2	15.5	187.5	2.42	10.8
8	2.34	2.9	9.8	1.19	2.2	15.4	185	2.39	10.9
9	2.28	3	9.5	1.16	2.16	14.4	170	2.24	11
10	2.32	2.9	9.7	1.18	2.18	15.2	180	2.34	10.9
11	2.36	2.8	9.9	1.21	2.21	15.6	190	2.45	10.8
12	2.3	3	9.6	1.17	2.17	14.8	175	2.29	10.9
13	2.29	3	9.55	1.17	2.16	14.6	172.5	2.26	10.9
14	2.26	3	9.4	1.15	2.14	14	176.5	2.18	11
15	2.38	2.7	10	1.23	2.23	15.8	195	2.5	10.8

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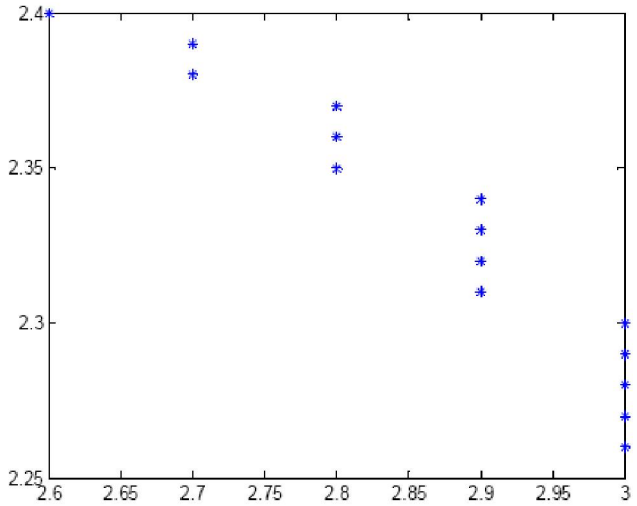

Figure 2 : The relevance of 30 m road run and high jump score

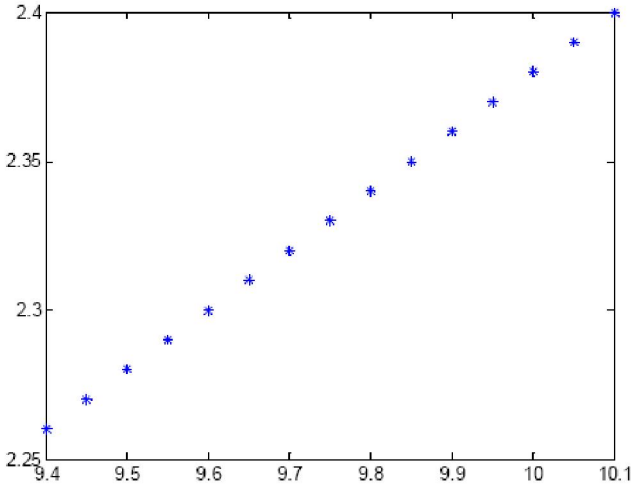

Figure 3 : The relevance of triple long jump and high jump score

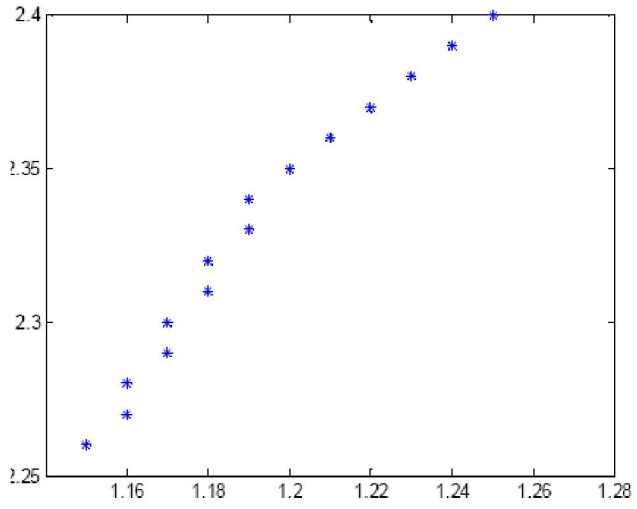

Figure 4 : The relevance of run-up reaching height and high jump score

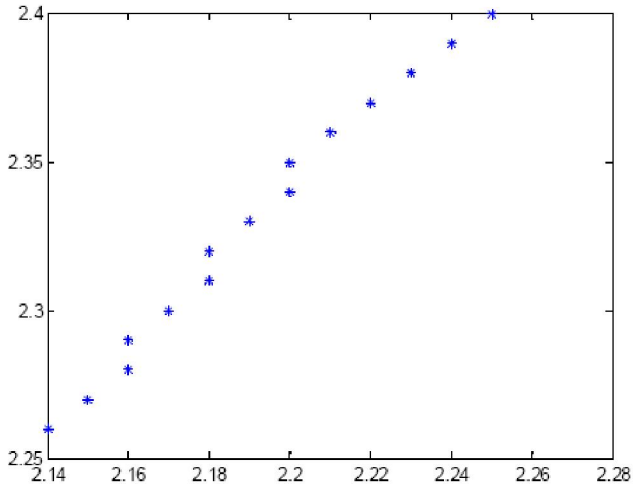

Figure 5 : The relevance of run-up 4-6 steps high jump and high jump score

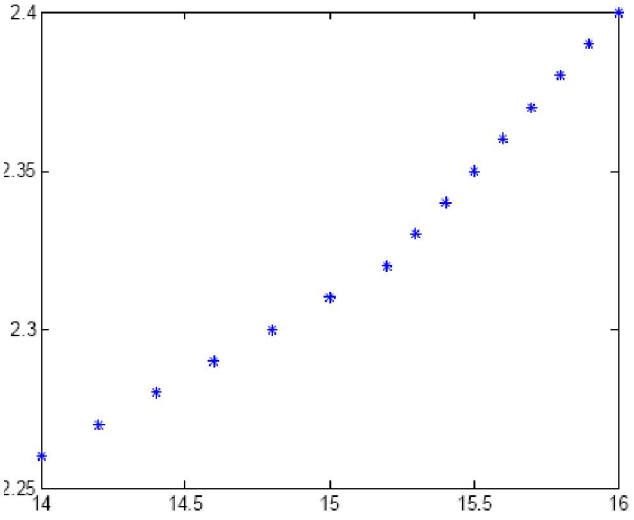

Figure 6 : The relevance of backward throwing shot and high jump score

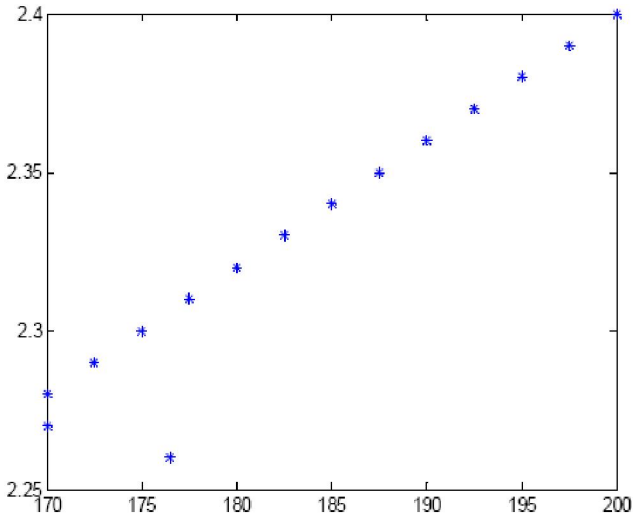

Figure 7 : The relevance of barbell deep squat and high jump score

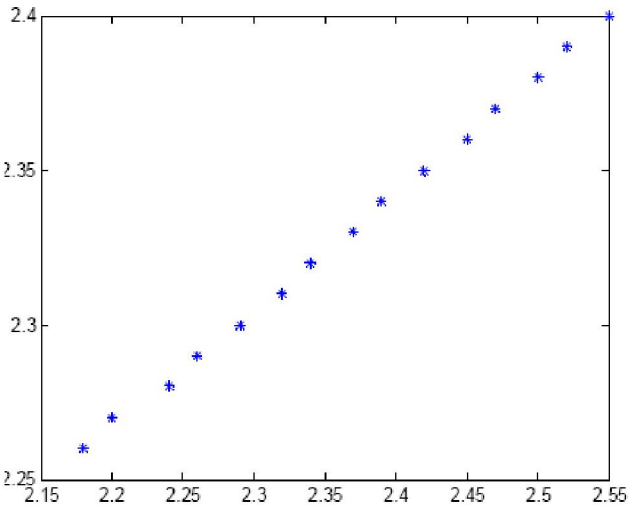

Figure 8 : The relevance of barbell half squat coefficient and high jump score

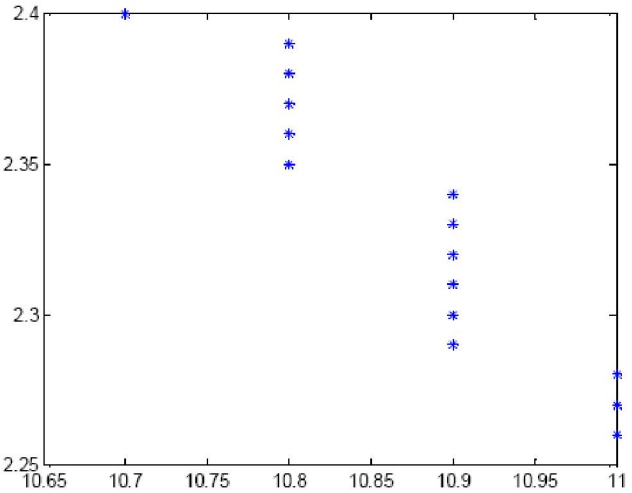

Figure 9 : The relevance of100m run and high jump scor

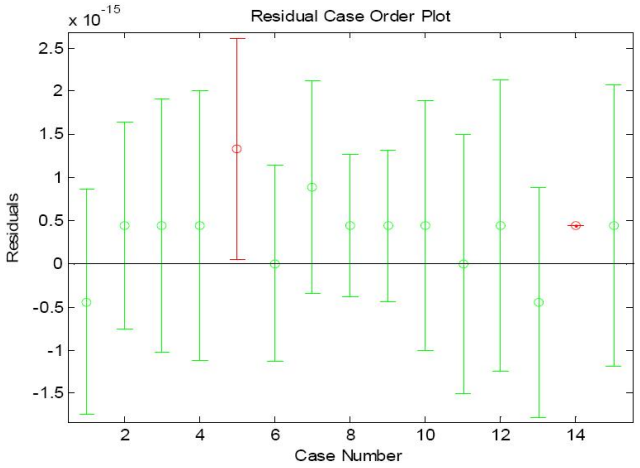

Figure 10 : Residual analysis diagram (Note: Black line points can be considered as outliers)

bring it to our regression equation and use MATLAB software to get a group of athlete's sports performance shown in TABLE 4 below:

The important factor affecting domestic men's high jump performance

Use MATLAB drawing tools to draw the X-Y scatter plots 11-17 of various physical indicators affecting athletes' sports performance and athletes' jump performance. It can be intuitively concluded from the Figure: there is no obvious linear correlation between high jump performance and jumper's physical fitness indicators. Thus we cannot take advantage of the linear regression equation to give prediction models.

The scatter plot of various physical indicators affecting athletes' high jump performance:

(2) We use the stepwise regression function in MATLAB software and come to the same result; Figure 13 shows that in the various physical fitness factors affecting the athlete's high jump performance only X3 namely run-up reaching height has a linear correlation

TABLE 3 : The comparison of original data and predicted data

No.	1	2	3	4	5	6	7	8	9
Original score Y(m)	2.4	2.31	2.39	2.33	2.37	2.27	2.35	2.34	2.28
Predicted score y^(m)	2.400	2.310	2.390	2.330	2.369	2.270	2.349	2.339	2.279
No.	**10**	**11**	**12**	**13**	**14**	**15**			
Original score Y(m)	2.32	2.36	2.3	2.29	2.26	2.38			
Predicted score y^(m)	2.319	2.360	2.2999	2.290	2.259	2.379			

TABLE 4 : The high jump results obtained by using the method of generating random numbers

No.	1	2	3	4	5	6	7	8
Score	2.365	2.295	2.3308	2.357	2.38	2.394	2.336	2.279
No.	**9**	**10**	**11**	**12**	**13**	**14**	**15**	
Score	2.280	2.296	2.377	2.295	2.373	2.294	2.390	

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TABLE 5 : The various quality indicators of domestic male high jumpers

No.	High Jump Performance	Standing Long Jump m	Standing Vertical Jump cm	Run-up reaching height	Barbell deep squat kg	Barbell half squat kg	100m	30 m
1 1	2.19	3.15	90	3.6	155	320	11.4	3.7
2	2.21	2.9	80	3.6	165	320	10.76	3.45
3	2.18	3.2	90	3.5	145	260	11.2	3.56
4	2.2	3.11	86	3.43	110	260	10.75	3.44
5	2.39	3.11	94	3.71	125	200	10.9	3.43
6	2.12	2.95	75	3.52	140	220	11.8	3.65
7	2.2	3	80	3.52	110	300	11.5	3.7
8	2.18	3.2	95	3.43	165	310	11.5	3.7
9	2.12	2.86	84	3.4	140	290	12.1	4
10	2.08	2.9	85	3.35	130	280	11	3.6
11	2	3.2	90	3.25	150	305	11.3	3.6

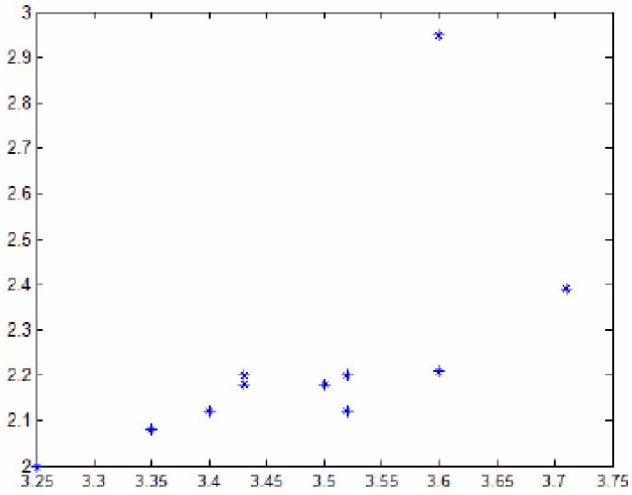

Figure 11 : The relevance of standing long jump and domestic men's high jump score

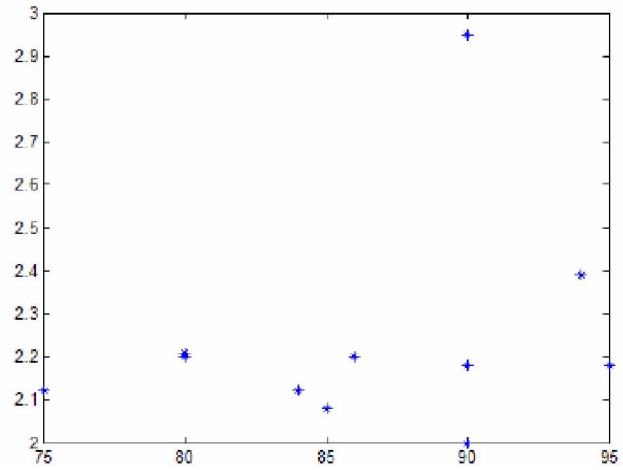

Figure 12 : The relevance of standing vertical jump and domestic men's high jump score

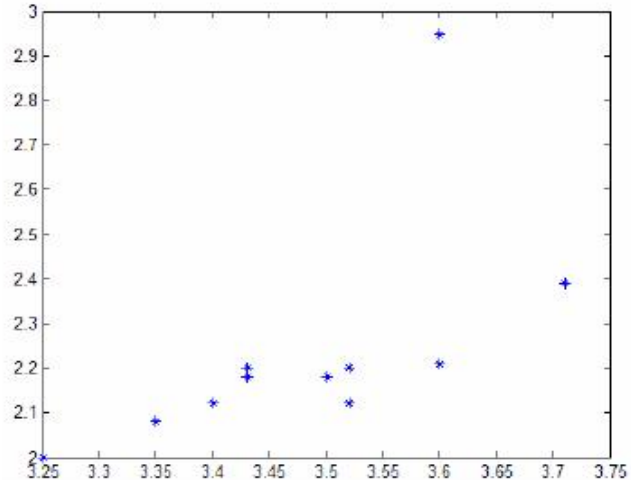

Figure 13 : The relevance of run-up reaching height s and domestic men's high jump score

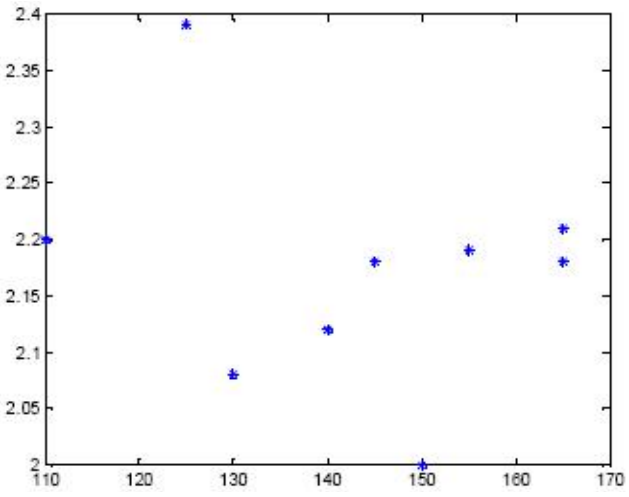

Figure 14 : The relevance of barbell deep squat and domestic men's high jump score

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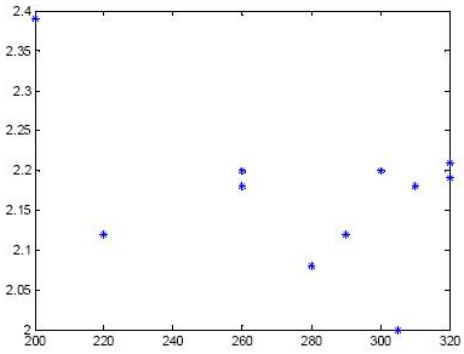

Figure 15 : The relevance of barbell deep squat and domestic men's high jump score

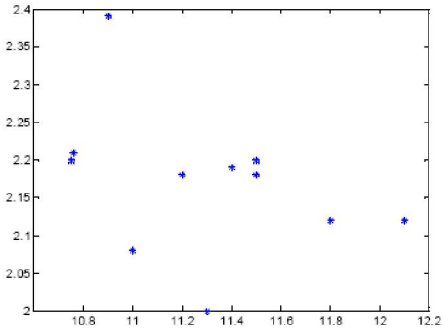

Figure 16 : The relevance of 100 m run and domestic men's high jump score

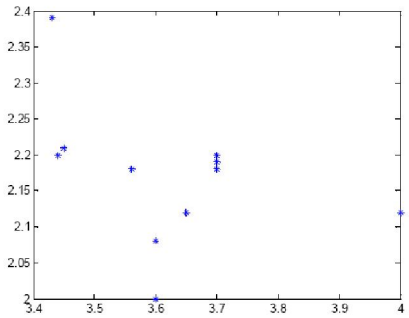

Figure 17 : The relevance of 30 m run and domestic men's high jump score

with the high jump results. So for the domestic men's high jump results, we can use nonlinear regression methods to predict.

Nonlinear regression equation: (1) Non-linear regression is one function fitting prediction method adopted when the linear correlation of more independent variables affecting dependent variable and the dependent variable is not strong. We can use the MATLAB built-in functions to give predictions. (2) Regression may use one of the following two commands: ① the order to determine regression coefficients: [betra, r, j] = nlinfit (X, Y, 'model', betr0) wherein the input data X, Y are [n, m] matrix and the n-dimensional column vector; betr0 is the initial value of the regression coefficients. Betra is the estimated regression coefficient, r (residual), J is the required data to estimate the prediction error. ② nonlinear regression command: nlintool (X, Y, 'model', beta0, aplha). The prediction results generated by nonlinear regression models are shown in TABLE 6.

TABLE 6 : The predicted model generated by nonlinear regression model

No.	1	2	3	4	5	6	7	8
Original score	2.19	2.21	2.18	2.2	2.39	2.12	2.2	2.18
Predicted score	2.2313	2.1923	2.1741	2.1686	2.3982	2.1257	2.2023	2.1485
No.	**9**	**10**	**11**					
Original score	2.12	2.08	2					
Predicted score	2.1041	2.1046	2.0198					

The parameters are as defined above, alpha is the significance level, the default value is 0.05. Command produces an interactive screen; the picture has the fitted curve and the confidence intervals of Y, as shown in Figure 18. For some nonlinear regression into we can also linear regression to predict; the comparison of domestic men's prediction performance and the real performance is shown in Figure 19.

Stepwise regression chart:

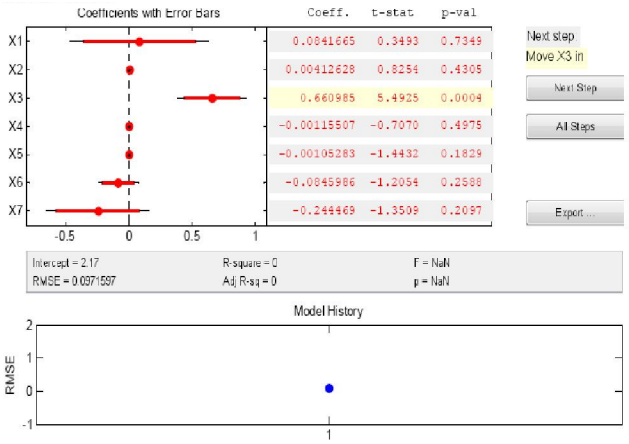

Figure 18 : The stepwise regression chart of the domestic men's quality indicators and high jump performance

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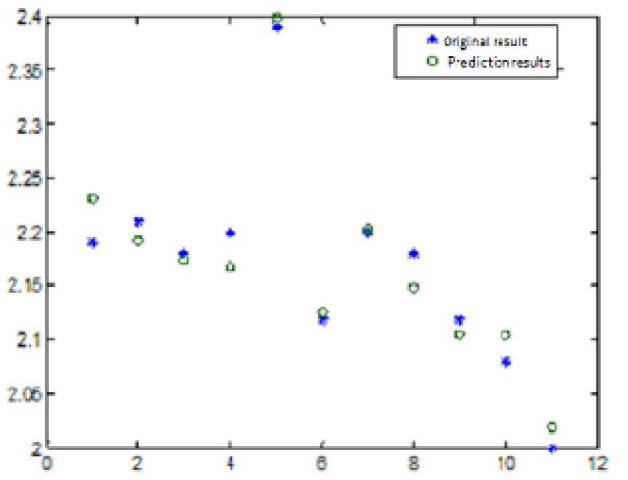

Figure 19 : The comparison chart of domestic men's predicted score and the real score

CONCLUSIONS

In this paper, through scatter diagram and multivariate linear model analysis, international men's various quality indicators are mainly related with triple long jump, run-up reaching height (clear height), run-up 4-6 steps high jump, backward throwing shot, barbell deep squats and barbell half squat coefficient. Domestic men's various quality indicators are greatly related with the run-up reaching height, while the correlation with the high jump, standing long jump, standing vertical jump, squat deep barbell, standing barbell, 100m run, 30m run are relatively not obvious.

According to the analysis, the physical indicators affecting jumpers also has limits in theory. We can use the logistic retardant growth model to predict the various quality indicators, predict the limits of various quality indexes, substitute the resulting limit values into the regression equation, and obtain the jumper's high jump limit value. We simply call this method as the multidimensional logistic retardant growth model. Due to space issues, this article doesn't write the specific model, but gives this prediction method, which is indeed effective.

But this situation does not always happen in real life. Though athletes attended high jump are world class athletes, the limit values of the physical indicators affecting high jump achievement can hardly be reflected to one person. When selecting new athletes, we still need to see a variety of physical indicators.

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