Multiple Analysis on Speed Distribution of World Elite Women 400m Athletes

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Abstract. By means of correlation analysis, regression analysis and cluster analysis, we study the every 50m segment result and total results of world elite women 400m athletes. Our purpose is to reveal the relations between different 50m phases and the final 400m result, and to find out the basic features of their speed distribution, in order to provide scientific references for our Chinese women athletes' 400m performances.

Key Words: women   400m   segment   multiple analysis

1. The Purpose of Study

Multivariate statistical analysis is a theory and method to solve multi-exponential problems by using symbolic statistic method. With the development of computer application technique and the stringent need of scientific research, multivariate statistical analysis is applied diffusely in geology, weather, hydrology, iatrology, industry, agriculture, economy and so on, and has become an effective way to solve practical problems. By searching the literature, we find that multiple analysis is used less in physical education field. This thesis analyzes and compares the every 50m segment time and the speed parameter of athletes taking part in women's 400m finals of the 6th and 7th World Championships in Athletics, analyzes the speed distribution of every 50m segment by multiple analysis and also reveals the speed distribution features of world elite women 400m athletes, in order to provide scientific evidence for our women athletes to control their speeds better, to improve their 400m results and to ameliorate their training methods.

2. The Subject and Method of Study

2.1. Subject

The subjects are the result, speed, and time parameter of the first eight athletes in women's 400m finals of the 6th and 7th World Championships in Athletics. Our research materials come from the data tested and published by Bryggman and Filo et al. (figure 1 and figure 2)

2.2. Method

We use multivariate statistic method to analyze the every segment result of world elite women 400m athletes, dealing the data with SPSS11.0.

3. Outcome and Analysis

3.1. Correlation Analysis of 50m Segment Time and 400m Result
3.1.1 Simple Correlation Analysis

Simple correlation analysis reflects the mightiness and weakness of the linear relation between two variables by numbers. Pearson simple correlation coefficient can be used to measure the linear correlation between scale variables. Through analysis, we find that the correlation coefficient $r=-0.258$ between reaction time of start and 400m result, which shows that starting reaction time has little effect on 400m result. The

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absolute values of the correlation coefficients between each 50m segment time and 400m result can be presented in the following descending order: |r8|＞|r6|＞|r5|＞|r7|＞|r2|＞|r1|＞|r4|＞|r3| (r1 stands for the first 50m segment, r2 stands for the second one, the rest may be deduced by analogy), which shows that the speed of the rest 200m is very important to the 400m result. The correlation coefficient r equals 0.903 (p<0.01) between the rest 200m and the 400m result. Therefore, to keep a high speed in the rest 200m of 400m is an essential pledge to win the game. Furthermore, the correlation coefficient r equals 0.753 (p< 0.01) between the eighth 50m segment time and the 400m result. Thus, on condition that the athletes have very close technical levels and specialized qualities，we can win the nip and tuck game by improving the final dash ability.

Figure 1   Table of Segment Time of Athletes Taking Part in Women's 400m Final of the 6th World Championship in Athletics (s)

Name	Result	Reaction Time	Segment (m)							
	(s)	（MSEL）	0–50	50–100	100–150	150–200	200–250	250–300	300–350	350–400
Freeman	49.77	226	6.54	5.72	5.64	5.80	6.00	6.20	6.60	7.04
Richards	49.79	167	6.50	5.56	5.76	5.88	6.08	6.24	6.60	7.00
Clark	49.90	143	6.67	5.56	5.56	5.96	6.08	6.24	6.60	7.08
Brewer	50.06	143	6.44	5.48	5.24	6.36	6.20	6.40	6.64	7.16
Ogunkoya	50.27	126	6.58	5.72	5.64	5.76	6.08	6.20	6.76	7.40
Fuchsova	50.66	159	6.62	5.56	5.52	5.96	6.24	6.48	6.76	7.36
Davis	50.68	127	6.58	5.72	5.88	6.00	6.20	6.41	6.60	7.16
Alexeva	51.37	167	6.48	5.76	5.40	5.84	6.24	6.56	6.96	7.96

Figure 2   Table of Segment Time of Athletes Taking Part in the Women's 400m Final of the 7th World Championship in Athletics (s)

Name	Results	Reaction Time	Segment (m)							
	(s)	（毫秒）	0–50	50–100	100–150	150–200	200–250	250–300	300–350	350–400
Freeman	49.67	193	6.37	5.63	5.68	5.92	6.08	6.10	6.53	7.17
Clark	49.74	203	6.60	5.61	5.69	5.93	6.06	6.12	6.45	7.08
Graham	49.92	182	6.43	5.50	5.62	5.86	6.19	6.34	6.60	7.20
Ogunkoya	50.03	157	6.40	5.59	5.68	5.84	6.13	6.16	6.68	7.40
Merry	50.52	193	6.49	5.56	5.71	5.96	6.13	6.33	6.75	7.40
Nazarova	50.61	176	6.53	5.59	5.75	6.05	6.38	6.44	6.62	7.08
Breuer	50.67	176	6.64	5.58	5.70	5.99	6.20	6.23	6.67	7.49
Kotlyarova	50.72	180	6.68	5.65	5.72	6.03	6.31	6.28	6.56	7.31

3.1.2 Partial Correlation Analysis

If we want to get the real relation between every two variables, we must calculate their correlation coefficient without the influences of other variables. In order to study the partial correlation between 400m result and eight 50m segment time, we can control the other seven 50m segment time and choose only one to compare with the total result by partial correlation analysis. The absolute values of partial correlation coefficients between each 50m segment time and 400m result can be arranged as: |r8|＞|r3|＞|r1|＞|r4|＞|r6|＞|r2|＞|r5|＞|r7|（figure 3）. Partial correlation analysis can reflect the correlation between each segment speed distribution and 400m result more objectively. From the order we can see that the eighth 50m segment time has the strongest partial correlation with the 40m result, which is in line with the outcome of the correlation. They commonly indicate that the dash ability in the eighth 50m segment has an important influence on the 400m result. Thus, we can develop the dash ability of 400m athletes through specialized trainings, the purpose of which is to increase the energy supply ability of body lactic acid energy system and the ability to tolerate lactic acid in order to improve the dash ability of the last 50m. The second one is the third 50m segment. The energy supply system of this segment changes gradually from phosphagen to glycolysis, which embodies in speed drop and time-consuming enhancement. In the third place is the first 50m segment; which reflects the accelerated ability after starting. The task of this segment includes two aspects: one is to conquer physical inertia, which makes the body start rapidly from a relative quiescent state

and gradually get a condign most displacement speed; the other is to conquer physiological inertia, which makes the body use phosphagen energy supply system firstly at the beginning of sports and then activate glycolysis energy supply system, providing relevant energy according to the need of athletic intensity. Characterized by its rapid metabolism, strong power-output and prior energy use, Phosphagen system constitutes the main energy source of stepped-up running. Thereby, the stepped-up running ability of an athlete after start actually reflects the energy supply ability of his phosphagen system. Although phosphagen energy supply system can maintain merely six-eight seconds, its energy supply rate is as 1.9 times as that of glycolysis energy supply system and is as 3.7 times as that of aerobic metabolism energy supply system. Therefore, the athletic speed produced by phosphagen energy supply plays an extremely important role in stepped-up running after start. Since the first 50m segment demands a high energy supply rate, it has to be supplied energy by phosphagen system only. In training we can develop the accelerated ability of 400m athletes by specialized training means, the purpose of which is to increase the energy supply ability of body phosphagen system and the ability of fast athletics. By means of repetitive training or intermittent training of ultimate and hypo-ultimate intensity whose athletic time are less than 10 seconds, we can increase the content of phosphocreatine and the activity of relevant enzyme.

Table 3 Partial Correlation Analysis of the 400m Results and the Eight 50m Segment Time of the 6th, 7th World Championships in Athletics

Segment	r1	r2	r3	r4	r5	r6	r7	r8
Correlative value	0.9688	0.9378	0.9722	0.9551	0.9032	0.9393	0.8124	0.9775

3.2. 3.2 Regression Analysis of 50m Segment Time and 400m Result (establishing a multiple linear regression model)

Multiple linear regression model is a linear regression model that has many explanatory variables and it is used to reveal the linear correlation between the explained variable and other variables. Since 400m result is affected by eight 50m segment time, we can establish an eight-variable linear regression model, using eight 50m segments to explain the 400m result.

In order to distribute the speed of the eight 50m segments reasonably, we need control the time of every segment according to the regression model, and, sum up the experience and get improvement in peacetime training.

One purpose of establishing a regression model is to control and to predict the object's future developments according to the regression model. In order to inspect the influence of every segment time on 400m result, we establish the regression model between every segment time and total result: $Y=2.160+0.975r1+0.995r2+0/966r3+0.902r4+0.950r5+1.079r6+0.769r7+1.045r8$. Since the adjusting coefficient of determination (0.995) is close to 1, we may come to the conclusion that the homogeneity of this regression model is very high, and the model can explain most part of the explained variable. The significance testing statistics show that F=412.110, P=0.0000<0.01; and the T-level of r1、r2、r3、r4、r5、r6、r7、r8 is10.338、7.205、10.982、8.533、5.567、7.244、3.686、12.274 in turn; moreover, the significance probability is less than 0.05, rejecting the H_O which think none coefficient of this regression is zero, this regression equation makes sense. The construction of this regression model, which makes controlling the whole process of training possible, would be a convenience for the coach to monitor and evaluate training and to arrange every 50m segment speed scientifically according to each athlete's 400m result.

3.3. Cluster analysis of 50m segment time and 400m result

Cluster analysis is to sort the sample data on the basis of the chosen variables, and it is an outcome of calibrating every variable synthetically. This thesis analyzes the original statistics with cluster analysis for every segment training of women 400m athletes. Analyzing table 4, we know that if we cluster the eight segments into four categories, the first and seventh 50m segments can be one, the second and third 50m segments can be another, the fourth, fifth and sixth segments is the third; and the eighth 50m segment is the last; if we cluster them into three, the first, fourth, fifth, sixth and seventh 50m segments can be one, the second and third 50m segments can be another, and the eighth 50m segment is the last. These two clusters have some points in common: the second and third segments make up one category, the fourth, fifth and sixth segments belong to another category and the eighth segment constitutes a category singly. The category made up of the second and third segments can be interpreted as a transition segment from stepped-up running

to midway running, thus, we can develop the running ability of these two segments by specialized training means, for example, the exercises of 150m-200m fast running and the trainings of multiple jump. The eighth 50m segment is the sprint stage, which needs to use specialized training to develop the athletes' abilities of anaerobic endurance and body resistance to acids. The category consisting of the fourth, fifth, and sixth 50m segments is a steady running stage, which needs to develop the athletes' ability of high-speed steady running through specialized training means.

Table 4   Members of Hierarchical Cluster Analysis

segment	4-clustered	3-clustered
1	1	1
2	2	2
3	2	2
4	3	1
5	3	1
6	3	1
7	1	1
8	4	3

4. Conclusion

4.1. The simple correlation analysis shows that to keep a high speed in the rest 200m of 400m is the key point of winning the game and on the condition that athletes have very close technical levels and specialized results, our athletes can win the nip and tuck game by improving their ability of the final dash. The partial correlation analysis shows that the absolute values of the partial correlation coefficients between every 50m segment time and 400m result can be arranged as: $|r8| > |r3| > |r1| > |r4| > |r6| > |r2| > |r5| > |r7|$, which is in line with the outcome of correlation analysis, and shows that to keep the speed of eighth 50m segment is very important.

4.2. In this thesis we establish a Multiple Linear Regression Model between eight 50m segment time and 400m result: $Y=2.160+0.975r1+0.995r2+0.966r3+0.902r4+0.950r5+1.079r6+0.769r7+1.045r8$. Tests show that this regression model is of outstanding significance and can reflect the relation between 400m result and every segment time truthfully, which provides scientific evidence for the coach to arrange the speed training of every 50m segment running scientifically.

4.3. If we cluster the eight 50m segment time of world elite women 400m athletes into three categories or four categories, we will find that they both reflect: the second and third segments are a transition from stepped-up running to midway running and these two segments are inseparable in training; the eighth 50m segment is the sprint stage, which needs to enhance the athletes' dash ability by specialized training; the fourth, fifth and sixth 50m segments make up a high-speed steady running segment, which needs the athletes to keep the ability of longtime steady running.

5. References

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