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## Men's tennis singles winning factors t test based on mathematical analysis

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### ABSTRACT

For major sport event analysis, it tends to focus on fighting process winning factors, and tennis competition analysis also should face such problems, by competitions process official summarized statistical indicator data, it can get a variety of huge data information, let researchers cannot more objective to analyze on it, in order to simplify it, it needs make classifications and discrimination on varieties of indicators, then makes researches on key factors, which can be doubly beneficial. In research, it firstly analyzes tennis competitions' techniques and tactics indicator factors, then makes T test on competition data, and gets 10 items very important winning factors, 6 items important winning factors, eliminates 4 items not important factors, which provides theoretical basis for future tennis competitions analysis. This paper takes tennis men singles competitions official statistical data as research objects, with an aim to extract fighting process winning factors indicators, in the hope of providing more convenient path for tennis competitions analysis.

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### KEYWORDS

Winning factor;  
T test;  
Significance;  
Indicator important degree;  
Mathematical statistics.

### INTRODUCTION

In tennis competitions, official through professional software handling, gives a variety of data, in the hope of providing data basis for future competition analysis, however how to extract researchers requirement from these data is people's concern, this paper does research on 16<sup>th</sup> Asian Games tennis men's singles competition winning factors, and extracts the big correlation degree data by utilizing mathematical statistics

For tennis competition winning factors research, lots of people have made efforts, just by their efforts let the event level get constant improvement, from which Luo Yang-Yang (2013) made statistical analysis of Wu Di in 2013 Australian Open Tennis Championship correla-

tion data, it got slow service speed, low receive quality, single playing, more unforced errors are the causes of their failure<sup>[1]</sup>; Zhi Yuan-Chun etc.(2013) made statistics and analysis of Azarenka performance status in Australian Open Tennis Championship, and got his winning reasons<sup>[2]</sup>; Ke Yong (2013) utilized questionnaire survey, field testing to analyze participated in the sixth city sports meeting top five province, city's 120 teenagers' men tennis athletes' service and receive techniques each indicator, and got different levels' tennis athletes' service and receive techniques have significant differences, which provided theoretical basis for tennis sports training and technical evaluation<sup>[3]</sup>.

This paper on the basis of previous research, it takes the 16<sup>th</sup> Asian Games tennis men singles' 38 competi-

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tions official statistical data as research objects, applies mathematical statistics method in extracting tennis men singles winning factors, it provides convenient methods for competitions analyzing and athletes' experience absorption.

### RESEARCH OBJECTS AND RESEARCH METHODS

#### Research objects

This paper takes the 16<sup>th</sup> Asian Games Tennis event Men's singles competition technical indicators as research objects, total competitions have 38 matches, in competition process, official website has statistics lots of indicator data that can reflect athlete's technical levels and affect competition result, takes carrier with these data, reflects competition process, it provides teaching material and experiences for tennis singles movement.

#### Research methods

Document literature: Search knowledge website about men's singles technical indicators researching aspects periodical documents and competition process restricted result success or failure technical indicators researching aspects reflection journal articles, extract regarding tennis men's singles competition winning key indicator factors from them, and provide guidance for competition summarization and sports technique innovation.

#### Expert interview

In order to extract authoritative key tennis men's singles competition winning influence factors, the paper applies expert interview making further refinement from document literature already extracted winning factors, which provides basis for data collecting and analysis convenience.

#### Imaging data analysis

In order to get more correct the 16<sup>th</sup> Asian Games tennis item men's singles competition data, the paper adopts imaging data analysis, it makes analysis of video, and implements further precise on data.

Mathematical statistics: In order to explore tennis item men's singles competition winning factors deeper significance, the paper adopts average value plus minus

standard deviation such data handling method, independent sample T test method and indicator data results comparative analysis method.

### MEN'S SINGLES WINNING INDICATORS ANALYSIS

Tennis fighting process mainly applied techniques are service technique, receive technique, stop volley technique and smash technique, in the following it makes statements for above four techniques, in the hope of providing basis for statistical indicators effective selection.

#### Service technique

The technique is an important technique in tennis, is one of attack process major score means, there are first serve and second serve in the competition, these two serve playing have top spin, flat, side spin and side top spin as well as other playing ways, serve ways can be also divided into overhand serve and underhand serve two types;

#### Receive technique

The technique divides into forehand and backhand receiving, similarly it has top spin, flat, back spin, side spin and mixing spin as well as other playing, in the receive process, it can directly drop volley or high volley, it can also make first strike and take the net or break the net. Therefore, tennis trajectory can appear as Figure 1 showed status, in figure 1, ① represents trajectory is long straight line ② represents trajectory is long diagonal ③ represents trajectory is short straight line ④ represents trajectory is short diagonal

Volley technique: The technique is also called blocking volley or volley, which also don't let ball drop in the ground in return process, the technique divides into forehand playing and backhand playing, while in practical application process, it mainly adopts back spin cut technique, if the technique classifies from return areas, it can be divided into far net volley, midfield volley and near net volley three types, in operation it can drop volley and make high volley.

#### Smash technique

The technique is a special playing method that returns opponents' high volley, its motions is similar to



Figure 1 : Receive process tennis crossing four kinds of trajectory status

serve, it can directly spike ace in attack process.

Tennis tactics playing methods have baseline, integrated and net three kinds of playing, from which baseline type refers to athlete basically keeps baseline smashing, less approaching the net, mainly relies on ball drop point, speed and rotational changes to control opponents, it will also occasionally approach the net when it appears ace opportunities; integrated refers to baseline and net two playing methods integrate using, athletes can combine opponents status to adopt different playing, adapts themselves to changing circumstances; net refers to athletes positively create all opportunities and conditions to approach the net, and attacks in the front of net.

Tennis tactics refer to athletes adopted strategies and actions in competitions so as to win the game or achieve corresponding expectation result; in tennis competition fighting, in order to make own party get more scores and interfere with opponents' scores, measures that adopted have following four strategies:

Reduce faults: Based on ball safety playing, the pursue more high level ace playing;

**Hit opponent backhand**

In tennis competition beginning –intermediate players' backhands may be their weakness, if it can attack their weakness, it is possible to cause opponent return fault, which arrives at the purpose of strategies;

Play cross-corner: Lowest net can reduce opponent approaching the net opportunities, longest cross-corner distance can reduce the opportunity of getting out of the bounds;

**Improve strength**

In competition, it should have scientific understanding of its own adept techniques, and play it into actual combat;

Through researching on tennis applications and strategies utilization in competition as well as reference documents' tennis competitions winning influence factors, the paper summarizes after expert interviewing that

TABLE 1 : Table competition winning factors indicators table

Winning linkage	Winning indicator	Symbol	Winning linkage	Winning indicator	Symbol
A Service linkage	First serve success rate	A1	B Break linkage	Break success times	B1
	ACE	A2		Break opportunity	B2
	Service directly ace	A3		Break success ratio	B3
	Double fault	A4	C Forced linkage	Forced error	C1
	First serve ace	A5		Winning score	C2
	First serve success times	A6		Forehand winning score	C3
	First serve scoring ratio	A7	D Ace linkage	Backhand winning score	C4
	Second serve score	A8		Net point	D1
	Second serve success times	A9		Volley direct score	D2
	Second serve scoring ratio	A10		Total score	D3

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there are 10 pieces of service winning factors indicators, 3pcs of breaking winning factors indicators, 4 pieces of avoiding forced errors winning factors indicators, 3pcs of restricting total scores scoring type indicators, as TABLE 1 show.

### INDEPENDENT SAMPLE T TEST PRINCIPLE AND STEPS

T test is used for measurements statistics on two different overall average values, with an aim to judge tested whether two independent samples derive from same average value entirety or not, if it tests on two groups of samples statistics, it should meet following three requests:

- (1) Tested two groups of samples are mutual independent from each other, no matching relationships;
- (2) Two groups of samples all derive from normal entirety;
- (3) Average value is significant descriptive statistics on testing.

When two groups of independent samples meet above three demands, next step should enter into T test actual operation steps, T test operation steps are as following show

#### STEP1. Establish original hypothesis and alternative hypothesis

Two independent samples T test original hypothesis  $H_0$  represents two entireties average values have no significant differences, mathematical expressions are as formula (1) show:

$$H_0 : H_0 : \mu_1 - \mu_2 = 0; H_1 : \mu_1 - \mu_2 \neq 0 \quad (1)$$

In formula(1),  $\mu_1$  and  $\mu_2$  respectively represents the first entirety average value and the second entirety average value.

#### STEP2. Select test statistics

For two entirety average value difference deduction basis is two entirety samples average value difference, which adopts two groups of samples average value differences estimated entirety average value difference, at this time it should focus on two samples' average value sampling distribution, if two entireties distribution are respectively  $N(\mu_1, \sigma_1^2)$  and  $N(\mu_2, \sigma_2^2)$ , then two

samples average value differences sampling distribution is also normal distribution, its average value is  $\mu_1 - \mu_2$ , variance is  $\sigma_{12}^2$ , but in different conditions,  $\sigma_{12}^2$  has different calculation ways, when the two conditions are respectively  $\sigma_1 = \sigma_2$  and  $\sigma_1 \neq \sigma_2$ , the former represents two entireties variance are unknown and equal, the latter represents two entireties' variance are unknown and not equal, therefore the former can adopt combined variance as two entireties variance estimation, their mathematical definitions are as formula (2) show:

$$Sp^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2} \quad (2)$$

In formula(2),  $S_1^2$  and  $S_2^2$  are respectively the first group of samples variance and the second group of samples variance  $n_1$  and  $n_2$  respectively represents the number of first group of samples and the number of second group of samples, then at this time two samples average value difference sampling distribution variance  $\sigma_{12}^2$  is as formula (30) show:

$$\sigma_{12}^2 = \frac{Sp^2}{n_1} + \frac{Sp^2}{n_2} \quad (3)$$

The latter case, it needs to respectively adopt their own variance, at this time two samples average value difference sampling distribution variance  $\sigma_{12}^2$  can be calculated by formula (4):

$$\sigma_{12}^2 = \frac{S_1^2}{n_1} + \frac{S_2^2}{n_2} \quad (4)$$

Therefore two entireties average value differences test statistics mathematical definition is as formula(5) show:

$$T = \frac{\bar{X}_1 - \bar{X}_2 - (\mu_1 - \mu_2)}{\sqrt{\sigma_{12}^2}} \quad (5)$$

In case  $\sigma_1 = \sigma_2$ , T statistics conforms to  $(n_1 + n_2 - 2)$  pieces of freedom degrees *t* distribution, in case  $\sigma_1 \neq \sigma_2$ , it conforms to revised freedom degree *t* distribution, revised freedom degree mathematical definition is as formula (6) show:

$$f = \frac{n_1 n_2 (n_2 S_1^2 + n_1 S_2^2)^2}{n_2^3 S_1^2 + n_1^3 S_2^2} \quad (6)$$

### STEP3. Calculate testing statistics observation value and probability $P$ value

The purpose of the step is calculating  $F$  statistics and  $T$  statistics observation value and their corresponding probability  $P$  value, applies SPSS software, it can automatically get  $F$  statistics and probability  $P$  value according to single factor variance analysis and can automatically input two groups of samples average value, numbers of samples and sampling distribution variance into formula(5), it gets  $T$  statistics observation value and corresponding probability  $P$  value.

### STEP4. Given significance level and makes decision

At first, make use of  $F$  test to judge two entireties variance is equal or not, and according to two variances numerical relationships, it decides sampling distribution variance and freedom degree calculation method and result, if  $F$  testing statistics probability  $P$  is less than significance level  $\alpha$  then it should refuse original hypothesis it gets the conclusions that two entireties variance have significant differences on the contrary it is thought that two entireties variances have no significant differences. Then, it applies  $T$  test to judge whether two entireties average value exists significant differences or not, if  $T$  test statistics probability  $P$  value is less than significance level  $\alpha$ , then it should refuse original hypothesis it gets two entireties average value has significant difference, on the contrary it is thought that two entireties have no significant differences. At last, according to statistical objects differences, it gets corresponding conclusions.

## TENNIS SINGLES WINNING INDICATOR MATHEMATICAL ANALYSIS

### Winning indicators' service technical statistics analysis

Due to service is the beginning that fighting two parties holding competition, meanwhile it also the attack hitting way, therefore, service technique is one of tennis competition winning ace key linkages, the paper

makes statistics on the 16<sup>th</sup> Asian Games men tennis singles service technical indicators, as Table 2 showed about the sports meeting 38 matches men singles fighting competitions service technique indicators statistics, in the hope of exploring service linkage winning factors, in the table, it lists winning party and fail party statistics indicator data, and make  $T$  test on two parties sample data differences, and proposed corresponding probability  $P$  showed difference significance degree.

From TABLE 2 data, it is clear that winning party first serve success rate is 57.47%, while the fail party first serve success rate is 56.29%, the former and the latter have 1.18% differences, from the perspective of first serve success times, winning party average each match first serve success times are 32.42, the fail party average each match first serve success times are 32.50, the gap between the two is only 0.08 time, and the two  $T$  statistics corresponding probability all above 0.05, that is to say, the two have no significant difference, therefore the first serve success rate and first serve success times can be regarded as non-significant winning factor.

Winning party second serve success times are 23.89, the fail party second serve success times are 25.32, the gap between the two is only 1.43 time, its statistics corresponding probabilities are all above 0.05, thereupon the second serve success times can also be regarded as non-significant winning factors. From above analysis, it is clear that first serve success rate, second serve success rate and second serve success times are not important indicators in winning factors, the above three indicators can be eliminated in data analysis and competition analysis.

From TABLE 2 data, it is clear than winning party ACE balls have 3.57 pieces while fail party has only 2.13 piece from the perspective of differences, it is clear that the gap between the two is 1.44 piece,  $T$  statistics corresponding probability is less than 0.05, therefore samples exist significant difference that Winning party leads the fail party in the number of ACE balls, it becomes winning factors relative important indicators, similarly analyze it is clear that double fault ball numbers and second serve score  $T$  statistics corresponding probabilities all are less than 0.05, it proves samples have also significant differences in the two indicators, therefore it can prove that numbers of ACE

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TABLE 2 : 38 matches' tennis men singles service linkage winning factor indicators data table

Indicator classification	Number of samples	Number of samples	T statistics	Difference significance degree
	38	38		
	Indicator value $\bar{x} \pm s$	Indicator value $\bar{x} \pm s$	T	P
A1	57.47 $\pm$ 9.13	56.29 $\pm$ 9.44	0.56	>0.05
A2	3.57 $\pm$ 3.05	2.13 $\pm$ 2.78	2.16	<0.05
A3	12.18 $\pm$ 3.89	8.78 $\pm$ 5.18	3.23	<0.01
A4	2.76 $\pm$ 2.31	3.97 $\pm$ 2.52	-2.18	<0.05
A5	24.11 $\pm$ 9.42	18.23 $\pm$ 8.51	2.85	<0.01
A6	32.42 $\pm$ 14.77	32.50 $\pm$ 10.66	-0.03	>0.05
A7	76.37 $\pm$ 9.32	54.00 $\pm$ 12.82	8.70	<0.01
A8	13.32 $\pm$ 5.08	10.03 $\pm$ 5.93	2.59	<0.05
A9	23.89 $\pm$ 9.96	25.32 $\pm$ 9.82	7.34	<0.01
A10	57.43 $\pm$ 11.74	37.42 $\pm$ 12.04	-0.63	>0.05

ball, numbers of double fault balls and second serve scores are all winning factors important indicators.

From TABLE 2 data, it is clear that winning party average each match direct ace is 12.18, and the fail party average each match direct ace is 8.78, the gap between the two is 3.40, T statistics corresponding probability is less than 0.01, therefore the samples have very significant differences, so first serve directly ace value is fighting competition winning very important indicator, by similar analyzing, it is clear that first serve ace, first serve ace rate and second serve ace rate T statistics corresponding probability is less than 0.01, so it can get that three samples have very significant differences, so service direct ace, first serve direct ace, first serve ace rate and second serve ace rate are winning factors very important indicators.

To sum up, it gets as TABLE 3 showed service indicators according to winning factors important degrees classification.

### Winning indicators break technique technical statistics analysis

In tennis competition, receive technique and ser-

TABLE 3 : Service linkage each indicator winning important degrees classification table

Important degree	Indicator	Important degree	Indicator
Very important	A3	Important	A4
Very important	A5	Important	A8
Very important	A7	Not important	A1
Very important	A9	Not important	A6
Important	A2	Not important	A10

vice technique are equal important, fighting total ace is accumulated by the two items, therefore the two are very important hitting techniques; in fighting competition process, players except should ensure service success, it needs to have hard service technique so as to interfere with opponent ace as well as create themselves more ace opportunities, so the paper makes statistical analysis of the 16<sup>th</sup> Asian Games tennis men singles 38 matches competitions break linkage, as TABLE 4 showed break linkage three single item indicators, respectively lists winning party and fail party two samples data, and make T test and significance level judging on them.

From TABLE 4 data, it is clear that three indicators' T statistics corresponding probabilities all are less than 0.01, it proves the three indicators independent samples data have very significant differences, that is to say, the three indicators all are very important winning factors, in order to indicate samples gap, the chapter adopts bar diagram way carrying out comparison, to clear show its differences, it needs to eliminate dimensions barriers, all adopt as TABLE 7 showed standardized formula to make data transformation.

$$X_1^* = \frac{X_1}{X_1 + X_2} \times 100, X_2^* = \frac{X_2}{X_1 + X_2} \times 100 \quad (7)$$

In formula(7)  $X_1^*$ ,  $X_2^*$  respectively represents winning party and fail party data after standardization,  $X_1$ ,  $X_2$  respectively represents winning party and fail party original data.

The gained difference bar diagram is as Figure 2

TABLE 4 : 38 matches' tennis men's singles break linkage winning factors indicators data table

Indicator classification	Number of samples 38	Number of samples 38	T statistics	Difference significance degree
	Indicator value $\bar{X} \pm S$	Indicator value $\bar{X} \pm S$	T	P
B1	4.82 ± 1.27	1.29 ± 1.37	11.62	<0.01
B2	8.71 ± 2.49	3.92 ± 4.06	6.19	<0.01
B3	59.37 ± 20.12	31.50 ± 31.43	4.60	<0.01

show.

In Figure 2, it shows winning party and fail party three winning factors indicators differences in break linkage, it gets winning party absolute advantages by comparing to the fail party.

**Winning indicators eliminate unforced technical statistics analysis**

Unforced errors refer to athletes in tennis competition, their faults generated and without any connections with opponents, the faults affect athletes final results in most time, therefore the paper makes statistics on unforced errors, winning ace, forehand winning ace and backhand winning ace in the 16<sup>th</sup> Asian Games tennis men's singles 38 competitions, in the hope of exploring unforced errors and winning linkage winning and fail two parties' differences, their statistical result is as TABLE 5 show.

From TABLE 5 data, it is clear that in each match

competition, winning party average unforced error is 26.37 time, and the fail party error times are 37.03 times, the two difference is 10.66 times, T statistics corresponding probability is less than 0.01, it proves two samples data have very significant differences, from the perspective of values, winning party error times are obvious less than fail party, so unforced errors are final result very important influence factors.

From the perspective of winning ace, winning party is 29.95 score, and the fail party is 20.79 score, the gap between the two is 9.16 score, T statistics corresponding probability is less than 0.01, it proves the two samples data have very significant difference, the winning party has an obvious advantage in numerical feature over the fail party, therefore winning ace is winning party getting success very important influence factor.

The average winning party forehand winning ace is 10.03 score, and fail party is 7.13 score, gap between the two is 2.9 score, the average backhand winning

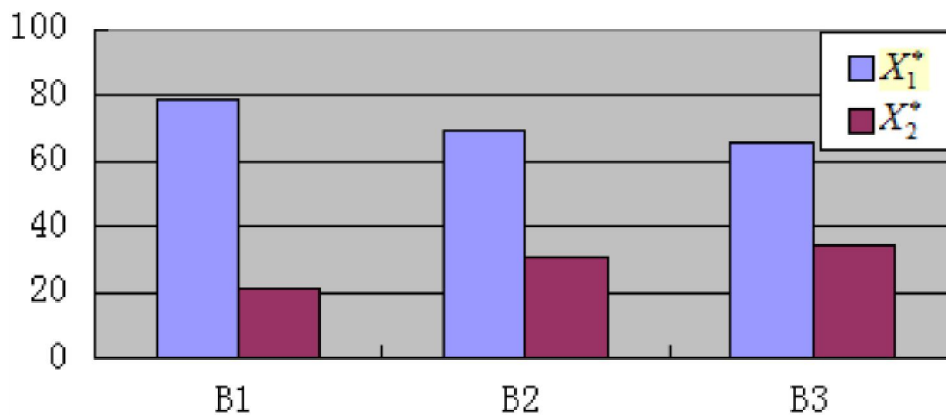


Figure 2 : Break linkage each winning factor fighting two parties' difference statistical figure

TABLE 5 : 38 matches tennis men's singles unforced errors and winning indicators statistical data table

Indicator classification	Number of samples 38	Number of samples 38	T statistics	Difference significance degree
	Indicator value $\bar{X} \pm S$	Indicator value $\bar{X} \pm S$	T	P
C1	26.37 ± 13.33	37.03 ± 11.19	-3.37	<0.01
C2	29.95 ± 8.26	20.79 ± 12.31	3.81	<0.01
C3	10.03 ± 4.23	7.13 ± 6.13	2.39	<0.05
C4	4.16 ± 3.29	2.74 ± 2.20	2.21	<0.05

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TABLE 6 : 38 matches tennis men's singles three scores status statistical data table

Indicator classification	Number of samples 38	Number of samples 38	T statistics	Difference significance degree
	Indicator value $\bar{X} \pm S$	Indicator value $\bar{X} \pm S$	T	P
D1	4.58 ± 3.75	2.63 ± 2.66	2.61	<0.05
D2	1.89 ± 2.12	1.08 ± 1.67	1.87	>0.05
D3	66.97 ± 16.29	47.16 ± 22.93	4.34	<0.01

ace in winning party is 4.16 score, fail party is 2.74 score, gap between the two is 1.42 score, from independent sample T test result, it is known that T statistics corresponding probabilities all are less than 0.05, it proves the two indicators samples have significant difference, therefore forehand winning ace and backhand winning ace is the important factor affects final result.

### To sum up

Unforced error and winning ace are tennis men's singles winning very important influence factors, and forehand winning ace and backhand winning ace are important factors, that is to say, tennis athletes should avoid unforced errors in fighting process, improve winning ace is the effective weapon in final winning.

### Score factor analysis

Tennis men's singles fighting competitions' net ace, volley direct ace and total ace affect the final result, three scores are very important, but which score is the most important one, it needs to search; only gets which scores are most important score, it can more convenient gain final victory, therefore, the chapter makes statistics on net ace, volley ace and total ace in the 16<sup>th</sup> Asian Games tennis men's singles competitions' 38 competitions, and indicates winning party and fail party above 3 indicators data samples T test and their corresponding probability *P*. Statistics result is as TABLE 6 show.

From TABLE 6 data, it is clear that winning party net average score is 4.58, fail ace is 2.63, the gap between the two is 1.95, and result got by independent sample T test is that probability *P* is less than 0.05, it proves samples data have Significant differences, that is to say, net ace is an important winning factor, winning volley average score is 1.89 score, fail party is 1.08 score, the gap between the two is 0.81 score, and result got by independent sample T test is that probability is more than 0.05 it proves samples data have no sig-

nificant differences, in tennis competition winning factor analysis, it can ignore the indicator, average winning party total score is 66.97 score, fail party is 47.16, the gap between the two is 19.81 score, T test result is probability *P* less than 0.01, from the perspective of test result, it is clear that samples data have very significant differences, so total score is essential indicator that should consider.

## CONCLUSIONS

This paper firstly analyzed tennis competitions technique and tactics, combined with document literature consulting and expert interview results, it summarized 20 pieces of tennis winning influence indicators factors; then stated T test principles and steps, which provided theoretical basis for competitions data handling; finally taken 16<sup>th</sup> Asian Games tennis men's singles 38 matches competitions 20 pieces winning factors reflection indicators data as carriers, applied T test method to carry out data analysis, it got 10 items very important winning factors, 6 items important winning factors, and eliminated 4 items not important factors, it provided theoretical basis for future tennis competitions analysis. It carried out analysis of the 16<sup>th</sup> Asian Games tennis men's singles 38 matches competitions data, from the perspective of data quantity, it can reflect tennis men's singles competitions commonalities, but it did not eliminate competitions scale and competition sessions generated changes, in order to make more scientific analysis of each match competition, it should apply methods in the paper to make individual treatments.

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