

# Application and Assessment of the Technical Effectiveness of Table Tennis Matches by the Principal Component Analysis (PCA) – Cluster Analysis (CA) Composite Model

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**Abstract:** This study uses the PCA - CA comprehensive evaluation training model to provide 8-week training guidance to 40 college table tennis players, and uses expert interviews, questionnaires and other methods to evaluate the rationality of the "new four-segment indicators" for athlete statistics. The evaluation aims to provide a richer theoretical reference basis for future table tennis training in colleges and universities. The results show that athletes and coaches have higher cognitive performance of PCA - CA method in practical training, and in the comparison of pre- and post-experiment tests, PCA - CA method can improve the competitive level of athletes. It was concluded that the PCA - CA method is more suitable for coaching high-level table tennis players, but has poor on-site guidance for low-level athletes. It is recommended that this method be implemented in the national team or provincial table tennis team.

**Keywords:** PCA-CA; Table Tennis Competition; College Students; Experiment.

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## 1. Introduction

Table tennis is known as the "national sport" in China and has a broad mass base [1]. As a confrontational sport across the net, table tennis is one of the common general courses in college physical education classes, and table tennis special courses are offered to college physical education students all year round to improve the sports skills of table tennis students. In addition, colleges and universities will also set up table tennis training teams to provide professional training to students with table tennis skills from various colleges in the school, so as to prepare for table tennis competitions at the municipal level and above and earn honors for the school. Judging from the current table tennis training methods in colleges and universities, many colleges and universities use traditional training methods to improve the competitive level of college athletes. This method can improve the competitive strength of athletes to a certain extent. However, athletes lack the ability to evaluate and analyze their own sports skills and are often unable to flexibly change their technical and tactical intentions when encountering equal opponents in the game, resulting in failure of the game. Therefore, this is a drawback of traditional methods in training. Currently, many scholars are constantly constructing a table tennis technical and tactical system to guide the training of table tennis teams. For example, Wu et al. (1988) [2] proposed the classic "three-stage index evaluation method", Li and Su (1998) [3] proposed the "ten-segment index evaluation method", Yang and Zhang (2014) [4] proposed the "four-segment index evaluation method", Zhang et al. (2018) [5] proposed the "dynamic three-segment index evaluation", Xiao et al. (2018) [6] proposed "Double Three-Phase Index Evaluation", Yu and Gao (2022) [7] proposed "Interactive Three-Phase Structure". These methods have enriched the analysis of technical and tactical implementation issues by scientific researchers and coaches to a certain extent, but they have also caused many

difficulties over time. For example, the scores of athletes on both sides of the competition do not correspond, resulting in a lack of competition data, and the evaluation methods are complex to operate, unable to clearly reflect the actual problems of athletes, etc. Therefore, this study will use the "New Four-Segment Index Statistical Method" constructed by Yin et al. (2023) [8] to count the technical and tactical gains and losses of college table tennis players. This method effectively makes up for the shortcomings of the above technical and tactical evaluation methods, problems, and can clearly divide the technical and tactical characteristics of each segment of athletes. Therefore, this study uses this method to collect technical and tactical data of table tennis players, and then combines the principal component analysis (PCA) - cluster analysis (CA) comprehensive evaluation training model to apply it to the guidance of college student table tennis training plans, and through an 8-week teaching experiment to test the effectiveness of PCA - CA guidance and training for athletes and the objectivity of athletes' competitive levels at each stage reflected in the "new four-stage indicators", aiming to bring richer theories to future training Reference.

## 2. Sample Selection and Methods

### 2.1. Selection of Samples

Forty male table tennis players from Shangrao Normal University's table tennis school team were selected as subjects. These athletes have a certain training foundation and have experience in participating in competitions.

### 2.2. Research Methods

#### 2.2.1. Expert Interview Method

Before implementing the PCA - CA method in the actual evaluation of table tennis skills and tactics, this study first conducted consultations (telephone interviews or mobile chat software to obtain relevant information) with table tennis

coaches (a total of 10 people) who have been engaged in front-line teaching and training all year round. In addition to asking for basic demographic information (age, education, professional titles, years of coaching, whether you have experience as an athlete, sports level, etc.), we also asked to learn more about the current scientific research results on analyzing the technical and tactical characteristics of table tennis players and their impact on on-the-spot competitions and how effective is the usual training and guidance? What are the main types of these research methods? In your coaching experience, in addition to the traditional table tennis technical and tactical analysis methods used in training and competitions, are there other interdisciplinary methods used in table tennis technical and tactical evaluation? Do you think these interdisciplinary approaches have any value in actual training and competition guidance? Can it clearly reflect athletes' competitive performance in actual operations? Do you think it is feasible for us to use the PCA - CA method to evaluate the competitive performance of the eight sub-observation indicators of the "New Four-Segment Indicators" in the study of table tennis technical and tactical characteristics? etc. In addition, in accordance with the requirements of the Declaration of Helsinki and in order to protect the privacy of the interviewees, we conducted interviews anonymously, and this was approved by the Adamson University Ethical Review Board (2024-04-EDU-107).

### 2.2.2. Questionnaire Survey Method

This study conducted a questionnaire survey on the opinions of PCA - CA method in the evaluation of table tennis skills and tactics through self-compiled athlete questionnaires. The content of the questionnaire is in addition to the basic demographic information characteristics of the athletes (age,

grade, sports level, training years, etc.); the main survey contents covered by the questionnaire include: In addition to the guidance of coaches, there are other scientific research methods for daily training. Auxiliary guidance training? Do you expect new table tennis research methods to be involved in training? Have you heard of the application of PCA - CA method in table tennis technical and tactical evaluation? Do you think this method has guiding value in actual competitions? Do you think it is necessary to provide scientific research services on athletes' competitive performance? If this method has certain auxiliary guidance value, will you promote it to other teammates and learn from it yourself to flexibly apply it in on-the-spot games and training? etc. The above main questions are evaluated and scored in the form of a four-level scale (for example, very good, 4 points; relatively good, 3 points; average, 2 points; not good, 1 point). A total of 40 questionnaires were distributed, 40 were recovered, and 40 were valid questionnaires, with an effective rate of 100%. Tables 1 to 3 below are the basic information of the questionnaire and the reliability and validity test tables.

(1) Validity test. The validity test of this study uses expert evaluation to ensure the validity of the questionnaire. The content of this questionnaire was scored by 5 industry experts. Each of the four main questions was set to 10 points, and the overall content of the questionnaire was set to 10 points. In addition, we used exploratory factor analysis (KMO and Bartlett test) for the structural validity of the questionnaire. The results show that the experts' scores for the question settings of the questionnaire content are between 7.8-8.8, and the comprehensive score is 8.2 (see Table 1); the KMO value of the structural validity of the questionnaire is 0.673>0.5 (see Table 2), indicating the content and structure validity of the questionnaire are good, and the next step can be carried out.

**Table 1.** Experts' ratings of the validity of the content of the questionnaire

content score	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	average score
Questionnaire question 1	8	9	8	8	9	8.4
Questionnaire question 2	9	9	8	9	9	8.8
Questionnaire question 3	8	8	7	8	8	7.8
Question 4	8	7	7	8	9	7.8
Comprehensive level of questionnaire	8	8	8	8	9	8.2

**Table 2.** KMO and Bartlett test

KMO value		0.673
Bartlett's test of sphericity	Approximate chi-square	137.44
	degrees of freedom	45
	Significance	0.000

(2) Reliability test. The reliability test of this study adopts reliability analysis. By randomly selecting 10 items of the questionnaire for testing, it is found that Cronbach's alpha coefficient is 0.767. According to the reliability coefficient between 0-1, the quantity the reliability of the table is relatively high and acceptable (see Table 3).

**Table 3.** Reliability statistics

Cronbach's $\alpha$ Alpha	Number of items
0.767	10

### 2.2.3. Experimental Method

(1) Selection of subjects. According to the arrangement of the training plan, 40 male table tennis players from Shangrao Normal University's table tennis school team were selected as subjects. These athletes have a certain training foundation and have experience in competition. In addition, the subjects were informed of the content of the study before the experiment, and the consent of the team members was obtained.

(2) Experimental equipment. table tennis rackets are provided by students with their own special rackets, table tennis balls are training balls from the school table tennis hall, and a table tennis serving machine (brand model: Pisces Super 3rd Generation).

(3) Experiment time and place. This experiment is arranged according to the school team training plan. The experimental training arrangement lasts for eight weeks, with training three times a week, and each training session lasts for 2 hours. The experimental training venue is the table tennis training hall on the first floor of the Comprehensive Training Hall of Shangrao Normal University.

**(4) Selection of test indicators.** Based on the training plan and the suggestions of some coaches, this study will select six technical and tactical offensive and defensive training indicators to facilitate athletes' understanding of tactical implementation. The test indicators are determined through the form of competitions. Statistics were made by comparing the differences between the coaches' use of the PCA - CA method and the training of athletes before and after the experiment. The test inspection indicators are serving, serving and attacking, receiving and serving, receiving and attacking, the ability to switch offense and defense in the fifth and sixth shots, and the ability to switch between offense and defense in a stalemate. These indicators were tested before and after the experiment, except that the serving and receiving techniques were tested 20 times each (the reason: involving different directions and landing points of serving and receiving), and the other techniques were tested 10 times each. By testing the athlete's batting success rate to score, a successful hit is worth one point, a failed hit is not counted, and the total is accumulated. In addition, the athletes' technical and tactical comprehensive ability test will be scored in the form of a competition, and the scoring method will be judged by professional teachers from the Sports College of Shangrao Normal University hired by the research team.

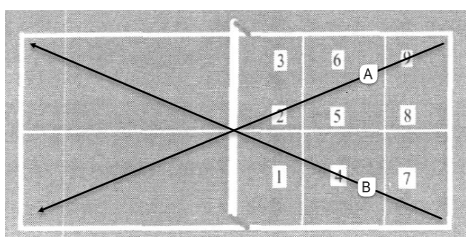


Figure 1. A schematic diagram of the athlete's attack route

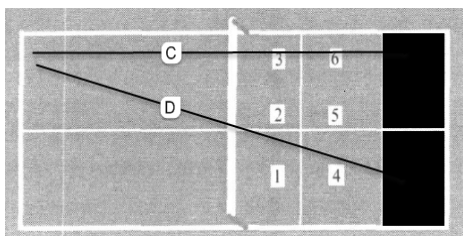


Figure 2. A schematic diagram of the serving and receiving route in motion

**Note:** Taking the right hand as an example, A represents the forehand attack route; B represents the backhand attack route; and AB is combined into a continuous conversion attack route map for the forehand and backhand. Taking serving in the left half of the station as an example, C represents the straight serving and receiving routes and areas; D represents the diagonal serving and receiving routes and areas; CD is combined to randomly serve and receive routes and areas for athletes.

**(5) Design of athlete training model.** The PCA - CA comprehensive evaluation model's training model for table tennis players in the experiment is shown in Figure 3.

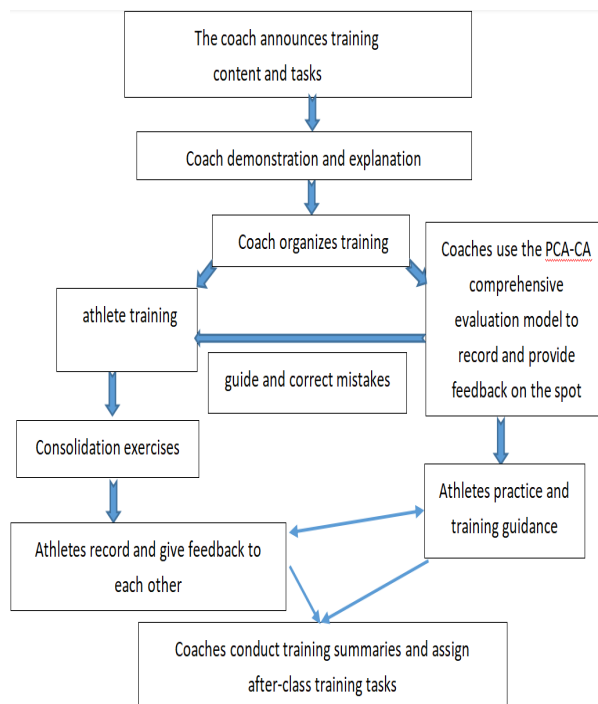


Figure 3. Training mode of PCA - CA comprehensive evaluation model in the experiment

## 2.2.4. Mathematical Statistics

The collected questionnaire and experimental data were first processed initially, and then the questionnaire data were subjected to descriptive statistics, and the experimental data were subjected to paired sample *t* -test.

## 3. Result Analysis and Discussion

### 3.1. Athletes' Cognitive Evaluation of Auxiliary Training Methods to Improve Competitive Level Before the Experiment

According to the statistical results in Table 4, among the athletes' cognitive performance on auxiliary training methods to improve competitive level before the experiment, the number of athletes who believed that they agreed or above was 28, accounting for 70%; the athletes who believed that they did not agree or below the number of people is 12, accounting for 30%. It can be seen that most athletes believe that auxiliary training methods can improve their competitive level in on-site competitions. Only a small number of athletes believe that auxiliary training methods cannot improve their competitive level. These athletes mainly have low training years and sports levels and cannot understand the impact of auxiliary training methods. The help brought by one's own competitive level is also due to the fact that there are few auxiliary training methods.

Table 4. Athletes' cognitive performance on auxiliary training methods to improve competitive level

	Strongly Agree	Agree	Disagree	Strongly disagree
Assisted training method	13 (32.5%)	15 (37.5%)	8 (20%)	4 (10%)

### 3.2. Athletes' Cognitive Evaluation of the "New Four-stage Index" in the PCA - CA Method before the Experiment to Improve the Overall Competitive Strength of the Game

According to the results of descriptive statistics in Table 5, it can be seen from the athletes' cognitive performance of the "new four-stage index" in the PCA - CA method to improve the overall competitive strength of the game that most athletes agree that the eight sub-indicators in the four-stage index are better in PCA. The CA Law has a certain impact on improving competition strength, and its comprehensive approval rate is as high as 74.7%. However, as the number of offenses and defenses in table tennis matches continues to increase, athletes' awareness of the "new four-segment indicators" of the PCA - CA method has also weakened. For example, in the transition stage and the stalemate stage, the corresponding

disapproval rates increased, with 13 people disapproving on the fifth beat, accounting for 32.5%; 11 people disapproving on the sixth beat, accounting for 27.5%; stalemate I 10 people disagreed with paragraph II, accounting for 25%; 11 people disagreed with paragraph II, accounting for 27.5%, and the overall disapproval rate accounted for 10.1%. It can be seen that in the current questionnaire survey of college table tennis players, the top four cricket balls are still the key to athletes' competition. Therefore, they have a deeper understanding of the PCA - CA method in the starting and receiving stages than in the transition stage and stalemate stage. On the one hand, these athletes have limited sports levels and training years, and do not have a deep understanding of techniques and tactics; on the other hand, as a newly introduced method, the PCA - CA method cannot be applied to the entire competitive process. Therefore, on the basis of strengthening the athletes' sports level, it is also necessary to strengthen the study of table tennis theoretical knowledge.

**Table 5.** Athletes' cognitive performance on the "new four-stage index" in the PCA - CA method to improve the overall competitive strength of the game

four-segment indicator	Eight sub-indicators	Strongly Agree	Agree	Disagree	Strongly disagree
send grab section	serve	17 (42.5%)	15 (37.5%)	8(20%)	0 (0%)
	The third beat	12 (30%)	18 (45%)	9 (22.5%)	1 (2.5%)
catching section	Return of serve	16 (40%)	14 (35%)	9 (22.5%)	1 (2.5%)
	Beat 4	19 (47.5%)	13 (32.5%)	8(20%)	0 (0%)
transition section	The fifth beat	13 (32.5%)	14 (35%)	13 (32.5%)	0 (0%)
	Beat six	19 (47.5%)	10 (25%)	9 (22.5%)	2 (5%)
Stalemate	Stalemate I	16 (40%)	14 (35%)	10 (25%)	0 (0%)
	Stalemate II	14 (35%)	15 (37.5%)	11 (27.5%)	0 (0%)
comprehensive		15.8 (39.4%)	14.1 (35.3%)	9.6 (24.1%)	0.5 (1.3%)

### 3.3. Analysis of Athletes' Competitive Level Test Results before and after the Experiment

According to the statistical data results in Table 6, in the 8-week experimental test, the PCA - CA comprehensive evaluation model was used to guide the daily training of table tennis players. According to the test results, it was found that there was no statistical difference between the athletes in the serving and receiving tests ( $P > 0.05$ ); in the actual test of serving and attacking, the test level of the athletes before the experiment was  $4.95 \pm 0.88$ , the post-experiment test level is  $5.50 \pm 1.20$ , there is a statistical difference ( $P < 0.05$ ), and other test indicators (receiving and attacking, transformation ability, stalemate ability and comprehensive competitive ability) also have statistical differences ( $P < 0.05$ ) after comparing before and after the experiment. It shows that using the PCA - CA comprehensive evaluation model to guide the training of table tennis players has a certain effect. However, further research found (see Table 7) that the athletes' sports level has a greater impact on the PCA - CA comprehensive evaluation model in actual training. The higher the sports level, the difference in the athletes' competitive performance before and after the experiment. The greater the difference; the lower the level, the opposite; for example, there is no difference in the competitive indicators

of athletes with level three sports levels before and after the experiment; there are certain differences in the experimental tests of level two athletes in terms of stalemate ability and comprehensive ability. There are no significant differences in other test indicators; there are significant differences in most test indicators between first-level athletes and national master-level athletes, indicating that the PCA - CA comprehensive evaluation model is more effective among high-level table tennis players. It has practical guiding significance. This is consistent with the results of the above analysis. Therefore, in future training, the PCA - CA method will be used to guide the training of athletes with low sports levels. It is recommended that coaches strengthen theoretical guidance and let students understand the guidance concept of the PCA - CA method, thereby improving their role in practical guidance; in addition, but also to strengthen technical training. Only when your own skills have reached a certain level, you can naturally understand the PCA - CA method throughout training; finally, for low-level athletes to use the PCA - CA method to guide training, it is recommended to extend the training time, by setting up 18 weeks or 36 weeks of training to observe whether there are significant differences among low-level table tennis players under the guidance of the PCA - CA method, which has more practical guiding significance. The discovery of whether this group of athletes is suitable for PCA - CA method to guide training can

be supported by objective and reasonable experimental data. This will have certain value in guiding athletes of different levels to provide appropriate training methods in the future.

**Table 6.** Statistical table of athletes' competitive level test results before and after the experiment

Test indicators	Test group (n=40 people)		T	sig	P
	Before test M ±SD	After the test M ±SD			
Serve/piece	11.43±1.81	12.20±2.42	-1.622	0.109	P > 0.05
Serve attack/piece	4.95±0.88	5.50±1.20	-2.344	0.022	P < 0.05
Return of serve/piece	11.55±2.17	12.45±2.81	-1.6	0.114	P > 0.05
Return of serve/attack	4.70±0.91	5.38±1.41	-2.545	0.013	P < 0.05
Conversion ability/piece	4.53±1.01	5.13±1.44	-2.16	0.034	P < 0.05
Stalemate ability/person	4.40±0.93	5.15±1.29	-2.982	0.004	P < 0.01
Comprehensive ability/point	61.48±7.81	67.00±8.59	-3.009	0.004	P < 0.01

**Table 7.** Statistical table of pre- and post-test results of athletes of different levels

Test indicators	Group/person	Level 3 athletes			Level 2 athletes		
		M ±SD	T	sig	M ±SD	T	sig
serve	Before experiment/40 people	9±0.71	-0.408	0.694	10.82±1.01	-1.227	0.226
	After test/40 people	9.2±0.84			11.18±0.96		
serve attack	Before experiment/40 people	4±0.71	0.408	0.694	4.91±0.68	-1.943	0.059
	After test/40 people	3.8±0.84			5.27±0.55		
Return of serve	Before experiment/40 people	8.2±0.84	0	1	10.86±1.04	-1.751	0.087
	After test/40 people	8.2±0.45			11.36±0.85		
return serve attack	Before experiment/40 people	3.4±0.55	-0.577	0.58	4.5±0.51	-1.604	0.116
	After test/40 people	3.6±0.55			4.77±0.61		
conversion ability	Before experiment/40 people	2.8±0.84	-1.342	0.217	4.64±0.66	-0.209	0.835
	After test/40 people	3.4±0.55			4.68±0.78		
Stalemate ability	Before experiment/40 people	2.6±0.55	-1.897	0.094	4.5±0.51	-2.248	0.03*
	After test/40 people	3.2±0.45			4.86±0.56		
Comprehensive ability	Before experiment/40 people	52±2.74	-1.573	0.154	55.23±4.34	-4.404	0.000**
	After test/40 people	55.2±3.63			63.64±3.79		

Note: \* p < 0.05 \*\* p < 0.01

Continued **Table 7.** Statistical table of pre- and post-test results of athletes of different levels

Test indicators	Group/person	first level athlete			National master level athlete		
		M ±SD	T	sig	M ±SD	T	sig
serve	Before experiment/40 people	12.9±0.74	-4.427	0.000**	15.0±1.0	-4	0.016*
	After test/40 people	14.3±0.68			17.67±0.58		
serve attack	Before experiment/40 people	5±0.67	-3.354	0.004**	6.67±0.58	-3.536	0.024*
	After test/40 people	6±0.67			8.33±0.58		
Return of serve	Before experiment/40 people	13.5±0.53	-6.647	0.000**	15.67±0.58	-7	0.002**
	After test/40 people	15.3±0.68			18.0±0		
return serve attack	Before experiment/40 people	5.2±0.42	-8.485	0.000**	6.67±0.58	-2	0.116
	After test/40 people	6.8±0.42			8.0±1.0		
conversion ability	Before experiment/40 people	4.6±0.52	-5.357	0.000**	6.33±0.58	-4.95	0.008**
	After test/40 people	5.9±0.57			8.67±0.58		
Stalemate ability	Before experiment/40 people	4.6±0.52	-5.692	0.000**	6.0±0	-7	0.002**
	After test/40 people	5.8±0.42			8.33±0.58		
Comprehensive ability	Before experiment/40 people	68.8±1.69	-7.707	0.000**	76.67±3.06	-2.236	0.089
	After test/40 people	75.4±2.12			83.33±4.16		

Note: \* p < 0.05 \*\* p < 0.01

### 3.4. Evaluation of the Effect of PCA - CA Method on Improving Athletes' Technical Level in Experimental Tests

According to the statistical data results in Table 8, it can be seen that the athletes' cognitive performance of using the PCA - CA method to guide and evaluate the training process on the effect of improving their competitive level can be seen. Among the six indicators tested after the athlete's experiment, most of the athletes were I almost agree with the PCA - CA method for guiding daily training. Among them, the conversion stage has the highest approval rate, accounting for 95%; followed by serving, receiving and attacking, and receiving and receiving, with approval rates of 92.5% and 90%

respectively; and finally, the ability to serve, attack, and hold on, with an approval rate of 92.5% and 90%, respectively. 87.5% and 85% respectively. Therefore, it can be seen that most athletes have certain benefits in improving their competitive level when coaches use the PCA - CA method to guide training. However, there are also some athletes who disagree. For example, the disapproval rates for holding power, serving and receiving are 15%, 12.5% and 10% respectively. This also illustrates a problem. The PCA - CA method is not completely suitable for every athlete in guiding practical training. Athletes should reasonably adjust training methods according to their own characteristics. Only when the athlete's own competitive level reaches a certain height, in order to better adapt to more advanced training methods.

**Table 8.** Cognitive performance of PCA - CA method on improving athletes' technical level in experimental tests

Evaluation index	Strongly Agree	Agree	Disagree	Strongly disagree
serve	15(37.5%)	22(55%)	2(5%)	1(2.5%)
serve attack	20(50%)	15(37.5%)	5(12.5%)	0 (0 %)
Return of serve	18 (45%)	18 (45%)	4 (10%)	0 (0 %)
return serve attack	20(50%)	17 (42.5%)	3 (7.5%)	0 (0 %)
conversion ability	21 (52.5%)	17 (42.5%)	2(5%)	0 (0 %)
Stalemate ability	18 (45%)	16 (40%)	5(12.5%)	1(2.5%)

### 3.5. The Impact of PCA - CA Method on Improving the Competitive Level of Table Tennis Players

The PCA-CA comprehensive evaluation model constructed is applied to the eight sub-indicators in the "New Four-Segment Indicators" to evaluate the impact of athletes' technical and tactical performance of various indicators in the game on the overall competitive level, and to Matches belonging to the same category are classified. At the same time, on the basis of evaluating the comprehensive competitive strength of each game, the PCA - CA method is used to verify the effect-level value of the PCA - CA method in guiding actual training through experimental methods. Therefore, this study conducts in-depth discussions on the statistical data results in Tables 6 to 10 above to explore training experiences with practical significance.

According to the results of the above analysis, most of the tested athletes have good cognitive performance on the PCA - CA comprehensive evaluation model training method, and the vast majority of the tested athletes agree with the practical application value of the PCA - CA method; the coaches said in the interview He also expressed great expectations that this method can mature as soon as possible and be applied to actual competitions and training for guidance. In the experimental study, through pre- and post-testing of the 8-week experiment, it was found that most of the athletes' selected test skill indicators had certain differences before and after comparison. Compared with before using the PCA - CA method, a certain improvement was achieved, which is very important for guidance. Training for table tennis players has certain effects. However, through in-depth excavation, it was found that the PCA - CA method is more beneficial to high-

level athletes, especially athletes at level one and above, when used to guide the training of table tennis players, which is of great help in improving their competitive level. Because the competitive level of this group of athletes is relatively high, they can understand the training tasks arranged by the coach in a timely manner, and can also refer to the evaluation module of the PCA - CA method to promptly discover problems at which stages they have, and with the assistance of the coach Compensate with specialized training. However, for low-level athletes, the effect may not be obvious, and there may even be signs of a decline in competitive level. This is mainly due to the fact that the technical and tactical levels of table tennis players with low sports levels are not mature enough and their technical performance is unstable. Methods such as PCA - CA are too abstract and difficult to understand. Therefore, these athletes need to further strengthen basic special training, and at the same time strengthen theoretical learning of table tennis-related training methods. Only by reaching a new height can they be more suitable for PCA - CA method to guide actual training. Therefore, this study believes that the PCA - CA comprehensive evaluation model is more suitable for high-level table tennis players for practical training guidance and should be promoted in the national table tennis team or provincial table tennis team. In addition, past research has found that there is currently no PCA - CA method used in table tennis or other cross-net confrontation sports where technical combat ability dominates. In other sports, it only evaluates the offensive and defensive strength of the game. Not used for practical guidance. The training methods used to improve training levels in table tennis mainly include "video feedback method" [9] and so on. Therefore, this study is of great value for the first time to use PCA - CA method for practical guidance of table tennis training.

## 4. Conclusion

Athletes and coaches have higher cognitive performance of the PCA - CA method in practical training, and in the comparison of pre- and post-experiment tests, the PCA - CA method can improve the competitive level of athletes; however, the PCA - CA method is more suitable for coaching high-level athletes. For horizontal table tennis, on-the-spot guidance is not effective for low-level athletes. It is recommended that this method be implemented in the national team or provincial table tennis team.

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