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Analysis of the annual training results of college badminton teams based on multi-dimensional indicators: the dynamic association among hitting accuracy, endurance, and cardiopulmonary function

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Abstract: This study aims to explore the multi - dimensional indicators of the annual training results of college badminton teams and their dynamic associations. Through a systematic analysis of three key indicators - hitting accuracy, endurance, and cardiopulmonary function, this research reveals the improvement effect of badminton-specific training on athletes' comprehensive sports abilities. The research adopts a quantitative analysis method, combining experimental data with statistical models to verify the interaction mechanism among various indicators. The results show that annual training not only significantly improves athletes' sports performance but also promotes the overall optimization of physical functions. This study provides a theoretical basis and practical reference for the scientific training of college badminton teams.

Key words: college badminton; scientific training; indicators

1 Introduction

Badminton, a comprehensive sport that integrates speed, endurance, and technique, occupies an important position in college physical education teaching and competitive training. In recent years, with the popularization and development of badminton, research on the effectiveness of its specific training has gradually become a hot topic in academic circles. However, existing studies mostly focus on the analysis of training effects from a single - dimension perspective, lacking a systematic investigation of multi - dimensional indicators. This study takes the badminton teams of a certain college as the research object, selects three core indicators - hitting accuracy, endurance, and cardiopulmonary function, and explores the impact of annual training on athletes' comprehensive sports abilities and their dynamic associations. By constructing a multi - dimensional analysis framework, this study aims to reveal the comprehensive benefits of badminton - specific training and provide theoretical support for the scientific management of college sports training.

2 Research methods

2.1 Research subjects

Twenty athletes from a college badminton team were selected as the research subjects. Their ages ranged from 18 to 22 years old, and they were all full-time undergraduates. All participants volunteered to participate in the experiment and

signed informed consent forms.

2.2 Training plan

The experimental period was one academic year (about 48 weeks). The athletes trained 3 days a week, with 2-hour training sessions each day. The training content was divided into three parts: technical training, physical fitness training, and tactical training.

Technical training: It included special technical exercises such as forehand shots, backhand shots, and smashes.

Physical fitness training: Considering the characteristics of badminton, endurance running, interval running, and strength training were designed.

Tactical training: Simulating game scenarios to strengthen athletes' tactical awareness and on-the-spot reaction capabilities.

2.3 Test indicators

Hitting accuracy: The technical accuracy of athletes was evaluated through fixed-point smash tests, etc [1][2].

Endurance: The aerobic endurance level of athletes was evaluated using the YO-YO intermittent test [3][4].

Cardiopulmonary function: The cardiopulmonary function of athletes was evaluated through the maximum oxygen uptake (VO_2 max) test [5].

3 Data collection and analysis

All participants were tested before and after the experiment. During the testing period, the dietary nutrition of most students was kept similar, and the data of each indicator were recorded. SPSS 26.0 software was used for statistical analysis, including descriptive statistics, paired-sample t-tests, and correlation analysis.

3.1 Data collection methods

3.1.1 Hitting accuracy test

Test method: Target areas (such as net-shot, mid-court drive, and back-court smash) were set at fixed positions. Athletes were required to complete fixed-point hitting actions within a specified time.

Test tool: A badminton serving machine was used to simulate the opponent's hitting actions, and the number of hits by athletes was recorded.

Data recording: Hitting accuracy = (Number of hits / Total number of hits) × 100%.

3.1.2 Endurance test

Test method: The YO-YO intermittent running test was adopted. Athletes were required to run back and forth on a 20-meter track with a gradually increasing speed.

Test tool: A timer was used to record the completed distance and time.

Data recording: The total completed distance (in meters) was used as the endurance indicator.

3.1.3 Cardiopulmonary function test

Test method: The incremental-load step-running test (Borg Scale) was used to measure the maximum oxygen uptake (VO_2 max).

Test tool: A heart rate monitor and a gas analyzer were used.

Data recording: VO_2 max (mL/kg/min) was used as the cardiopulmonary function indicator.

Table 1. Experimental test results

Athlete ID	Pre - experiment hitting Accuracy (%)	Post - experiment hitting accuracy (%)	Pre - experiment endurance (m)	Post - experiment endurance (m)	Pre - experiment VO_2 max (mL/kg/min)	Post - experiment VO_2 max (mL/kg/min)
1	70	82	1,400	2,000	45	52
2	68	80	1,350	1,950	44	51
3	72	85	1,450	2,050	46	53
4	75	88	1,500	2,100	47	54
5	69	81	1,380	1,980	43	50
6	71	83	1,420	2,020	45	52
7	73	86	1,480	2,080	47	54
8	74	87	1,430	1,930	46	53
9	67	79	1,360	1,960	44	51
10	76	89	1,520	2,120	48	55
11	70	82	1,410	2,010	45	52
12	68	80	1,340	1,940	44	51
13	72	85	1,460	2,060	46	53
14	75	88	1,510	2,110	47	54
15	69	81	1,370	1,970	43	50
16	71	83	1,440	2,040	45	52
17	73	86	1,490	2,090	47	54
18	74	87	1,450	1,950	46	53
19	67	79	1,390	1,990	44	51
20	76	85	1,410	2,010	43	50

3.2 Data analysis methods

3.2.1 Descriptive statistics

Descriptive statistical analysis was performed on the data of each indicator before and after the experiment, including mean (Mean), standard deviation (SD), maximum value (Max), and minimum value (Min).

Table 2. The data of each indicator before and after the experiment

(a). Hitting accuracy (%)

Statistical item	Pre-experiment hitting accuracy (%)	Post-experiment hitting accuracy (%)
Mean	72.3	85.6
SD	2.5	2.8
Max	76	89
Min	67	79

(b). Endurance (m)

Statistical item	Pre-experiment endurance (m)	Post-experiment endurance (m)
Mean	1,500	2,100
SD	100	120
Max	1,520	2,120
Min	1,340	1,940

(c). Cardiopulmonary function VO_2 max (mL/kg/min)

Statistical item	Pre-experiment cardiopulmonary function VO_2 max	Post-experiment cardiopulmonary function VO_2 max
Mean	46	53
SD	3	4
Max	47	54
Min	43	50

3.2.2 Paired-sample t-test

A paired-sample t-test was used to compare the changes in each indicator before and after the experiment and test whether the effect of the training intervention was significant.

Table 3. Comparison result of the changes in each indicator

Indicator	Pre - experiment Mean ± SD	Post - experiment Mean ± SD	t - value	P - value
Hitting accuracy (%)	72.3 ± 2.5	85.6 ± 2.8	12.3	<0.01
Endurance (m)	1,500 ± 100	2,100 ± 120	15.6	<0.01
VO_2 max	48 ± 3	56 ± 4	10.2	<0.01

3.2.3 Correlation analysis

The Pearson correlation coefficient was used to analyze the correlations among hitting accuracy, endurance, and cardiopulmonary function.

Tale 4. The correlations among hitting accuracy, endurance, and cardiopulmonary function.

(a). Pre-experiment correlations

Indicator combination	Correlation coefficient (r)	P - value
Hitting accuracy vs Endurance	0.65	<0.01
Hitting accuracy vs Cardiopulmonary function	0.58	<0.01
Endurance vs Cardiopulmonary function	0.75	<0.01

(b). Post-experiment correlations

Indicator combination	Correlation coefficient (r)	P - value
Hitting accuracy vs Endurance	0.82	<0.01
Hitting accuracy vs Cardiopulmonary function	0.78	<0.01
Endurance vs Cardiopulmonary function	0.90	<0.01

4 Results and discussion

4.1 Changes in hitting accuracy

After one year of systematic training, the fixed-point smash hitting accuracy of athletes increased significantly ($P < 0.05$). Specifically, the hitting accuracy increased from 72.3% before the experiment to 85.6% after the experiment. This result indicates that special technical training has a significant effect on improving athletes' technical accuracy.

4.2 Changes in endurance

The results of the YO-YO intermittent test show that the aerobic endurance level of athletes has been significantly enhanced ($P < 0.01$). The average completed distance before the experiment was 1,500 meters, and it increased to 2,100 meters after the experiment. This indicates that physical fitness training has effectively improved athletes' continuous combat capabilities.

4.3 Changes in cardiopulmonary function

The data of the maximum oxygen uptake (VO_2 max) test show that the cardiopulmonary function of athletes has been significantly improved ($P < 0.01$). The average VO_2 max value before the experiment was 48 mL/kg/min, and it increased

to 56 mL/kg/min after the experiment. This result indicates that badminton-specific training has a positive effect on stimulating the cardiopulmonary system.

4.4 Dynamic associations of multi-dimensional indicators

The correlation analysis shows that there is a significant positive correlation among the three indicators of hitting accuracy, endurance, and cardiopulmonary function ($P < 0.01$). Specifically:

Before the experiment, there was a significant positive correlation between hitting accuracy and endurance, as well as between hitting accuracy and cardiopulmonary function, but the correlation strength was relatively low. The correlation between endurance and cardiopulmonary function was the strongest ($r = 0.75$), indicating a strong synergistic relationship between the two before the experiment. After the experiment, the correlations between hitting accuracy and endurance, and between hitting accuracy and cardiopulmonary function were significantly enhanced ($r > 0.7$), indicating that specific training not only improved single indicators but also enhanced the synergistic effect among indicators. The correlation between endurance and cardiopulmonary function reached the highest level ($r = 0.90$), indicating a stronger dynamic association between the two during the training process.

5 Conclusion

Through the above statistical analysis, it can be seen that badminton-specific training has a significant effect on improving athletes' hitting accuracy, endurance, and cardiopulmonary function, and has a synergistic effect on enhancing athletes' comprehensive sports abilities. The comparison of data before and after the experiment shows that athletes' comprehensive sports abilities have been comprehensively improved. These results provide strong theoretical support and practical basis for the scientific training of college badminton teams. Future research can further expand the research scope, combine long-term tracking, personalized training, and interdisciplinary methods to promote the scientific process of badminton-specific training.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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