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การออกแบบโปรแกรมฝึก SPARQ เพื่อพัฒนาประสิทธิภาพการเล่นเทเบิลเทนนิสของนักศึกษามหาวิทยาลัย

DESIGNING SPARQ TRAINING PROGRAM TO ENHANCE TABLE TENNIS PERFORMANCE OF UNIVERSITY STUDENTS

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บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อออกแบบโปรแกรมฝึก SPARQ เพื่อพัฒนาประสิทธิภาพการเล่นเทเบิลเทนนิสของนักศึกษามหาวิทยาลัย การวิจัยนี้เป็นการวิจัยแบบผสมผสาน ประชากรประกอบด้วยนักศึกษามหาวิทยาลัยจำนวน 120 คน และครูผู้สอนเทเบิลเทนนิสจำนวน 18 คน จากมหาวิทยาลัย 5 แห่งในเมืองซูโจว มณฑลเจียงซู โดยนักศึกษาทั้ง 120 คนจะเข้าร่วมทดสอบวิ่ง 50 เมตร ผู้ที่มีผลการทดสอบต่ำสุด 30 คนจะถูกคัดเลือกเป็นกลุ่มตัวอย่าง โดยวิธีการสุ่มตัวอย่างแบบเป็นระบบ กลุ่มตัวอย่างแบ่งเป็นกลุ่มทดลอง 15 คน และกลุ่มควบคุม 15 คน โปรแกรมฝึก SPARQ ดำเนินการเป็นเวลา 12 สัปดาห์ สมรรถภาพทางกายและทักษะ เทเบิลเทนนิสจะถูกประเมินก่อนการฝึก และในสัปดาห์ที่ 6 และสัปดาห์ที่ 12 เพื่อประเมินผลของโปรแกรมฝึก SPARQ การวิเคราะห์ข้อมูลใช้ค่าเฉลี่ย ส่วนเบี่ยงเบนมาตรฐาน การวิเคราะห์ความแปรปรวนแบบวัดซ้ำทางเดียว การทดสอบเปรียบเทียบรายคู่แบบบอนเฟอร์โรนี และการทดสอบทีแบบอิสระ ผลการวิจัยพบว่า กลุ่มทดลองมีสมรรถภาพทางกาย (ไม่รวมเวลาตอบสนองของมือ) และตัวชี้วัดทักษะเฉพาะด้านเทเบิลเทนนิสดีขึ้นอย่างมีนัยสำคัญเมื่อเทียบกับกลุ่มควบคุมภายหลังการฝึก ($p<0.05$) ผลการวัดประสิทธิภาพทั้งในช่วงการทดสอบกลาง (สัปดาห์ที่ 6) และการทดสอบหลัง (สัปดาห์ที่ 12) ของกลุ่มทดลองแสดงให้เห็นถึงการพัฒนาที่ดีขึ้นอย่างมีนัยสำคัญเมื่อเทียบกับการทดสอบก่อน ($p<0.05$) โดยมีการพัฒนาเพิ่มขึ้นตามเวลา ผู้เชี่ยวชาญและผู้ฝึกสอนต่างชื่นชมในความสมเหตุสมผลเชิงโครงสร้างและขั้นตอนการฝึกที่เป็นลำดับขั้น

คำสำคัญ: โปรแกรมฝึก SPARQ, ประสิทธิภาพเทเบิลเทนนิส, นักศึกษามหาวิทยาลัย

Abstract

This study aimed to design and evaluate the efficacy of SPARQ training programs in enhancing college students' table tennis performance. Using a mixed-method design, 120 college students and 18 table tennis coaches from five universities in Suzhou, Jiangsu Province were enrolled as subjects. Thirty participants with the poorest performance were selected through a 50-meter sprint test and randomly assigned to either an experimental group (n=15) or a control group (n=15). The experimental group underwent 12 weeks of SPARQ training, with physical fitness and table tennis skills assessed before intervention and at weeks 6 and 12. Data analysis employed repeated-measures ANOVA, Bonferroni post-hoc tests, and independent

samples t-tests. The results demonstrated that the experimental group exhibited significantly superior performance to the control group in physical fitness (excluding hand reaction speed) and specialized table tennis skill indicators ($p<0.05$). Both performance metrics showed marked improvement from baseline levels at weeks 6 and 12 ($p<0.05$), with the magnitude of enhancement progressively increasing as training duration extended. The expert and coaching team endorsed the structural rationality and progressive design of this training protocol.

Keywords: SPARQ training program, Table tennis performance, University student

Introduction

Table tennis, as China's "national sport," carries profound historical significance and a broad popular base. The pyramid-style talent cultivation model from grassroots sports schools to the national team ensures a continuous supply of elite athletes. This scientifically rigorous training system, combined with ongoing technological innovations, has collectively supported the outstanding performance of the Chinese table tennis team in international competitions. In the field of higher education, table tennis has become one of the most popular sports among college students due to its high safety and strong appeal (Kuan, 2024). Studies indicate that table tennis not only enhances physical fitness and coordination but also cultivates focus, psychological resilience, strategic thinking, and teamwork spirit (Liu, 2025). However, the current development of table tennis in Chinese universities faces practical challenges such as insufficient facilities and weak faculty strength (Wang, 2025), while outdated teaching content and monotonous methods also hinder the improvement of teaching effectiveness (Javed, 2023).

While existing research has highlighted the positive impact of table tennis on college students' physical and mental development, several gaps remain in current literature. First, the SPARQ training program - a systematic approach designed to enhance specialized athletic performance through neuromuscular adaptation - has yet to be applied in table tennis research or practice. Second, there is a lack of quasi-experimental longitudinal studies on table tennis training, making it difficult to reveal the dynamic process of training effects over time. Third, most existing training methods still separate physical conditioning from technical training, failing to achieve effective integration between the two.

To address existing gaps, this study aims to design and validate an SPARQ training program, investigating its efficacy in enhancing college students' table tennis performance through neuromuscular adaptation mechanisms. Employing a quasi-experimental longitudinal design, we examine trajectory changes during a 12-week training cycle while integrating physical fitness development with specialized technical training. This research not only contributes to enriching the theoretical framework of sports training science but also provides empirical evidence for reforming table tennis instruction in higher education institutions.

Research Methodology

This study adopted a quasi-experimental design, comparing the experimental group and the control group before, during (6 weeks), and after the experiment (12 weeks) to explore the impact of SPARQ training on college students' athletic performance. This study aims to improve the physical fitness and skill performance of university students by designing SPARQ training program.

Population

The population of this research was 120 first-year male students majoring in table tennis from 5 universities in Suzhou, Jiangsu Province and 18 table tennis teachers.

Sample

This study employed a questionnaire survey method to investigate 120 male first-year table tennis majors from five universities in Suzhou, Jiangsu Province, and conducted interviews with 18 table tennis coaches. All 120 students participated in a 50-meter sprint speed test. Based on test performance rankings from lowest to highest, systematic sampling was used to select the bottom 30 students as study subjects. These participants were then randomly assigned into an experimental group (n=15) and a control group (n=15) to ensure comparability before intervention and minimize interference from selection bias on experimental outcomes.

Research Instruments

The research instruments employed in this study consisted of the following:

1. Men's table tennis University student’s questionnaire.

Through systematic review of relevant literature, we developed a questionnaire specifically designed for male college table tennis athletes to assess their physical fitness level and fundamental techniques.

2. Interview questionnaire for table tennis teachers.

This study employed an open-ended questionnaire design for interviews with table tennis coaches to investigate the current status and challenges of physical fitness levels and technical skills faced by male college students in table tennis sports.

3. Expert interview questionnaire

We designed an expert interview questionnaire to collect the current situation and challenges of male college students in table tennis skills and physical fitness through open questions.

4. Focus Group Outline.

Through expert focus group discussion, relevant training plan is developed and the feasibility of the training plan is ensured through focus group discussion.

5. SPARQ training program.

Through the focus group discussion, a specific training plan will be developed. The specific training plan aims to improve the skills and physical fitness of male university students in table tennis. The training time is 12 weeks.

6. Physical fitness test.

Designing physical fitness testing methods for speed, strength, agility, reaction time, and rapid initiation.

6.1 Speed : The 30-meter sprint test and 3.5-meter lateral movement test were conducted using a stopwatch to assess short-distance acceleration and movement speed.

6.2 Power : The continuous jump test and rotational explosive power test were conducted. The continuous jump test measured the number of jumps in one minute, while the rotational explosive power test measured the distance thrown by rotating a ball. These two tests assessed lower limb explosive power and waist-abdominal rotational explosive power.

6.3 Agility : The "T" -type running test and pro sensitive running test. The "T" -type running test method is a quick vertical run and lateral sliding step, using a stopwatch to assess the agility of the lower limbs, which is important for the ball to be hit in motion.

6.4 Reaction : The reaction ball test and light-hand reaction time test. The test is completed by a reaction time machine to assess hand-eye coordination and reaction time, which are important for hitting and receiving a ping-pong ball.

6.5 Quickness : Two-point touch test and "rice" run test. This test uses a stopwatch to calculate the number of touch times in one minute and the time of "rice" run. This test is used to evaluate the instantaneous starting ability of table tennis, which is important for receiving serves and holding back table tennis.

7. Table tennis skill test.

The skill assessment for male university table tennis players aims to evaluate their hitting ability, requiring the ball to be struck into a designated area.

7.1 One-minute forehand two-point rally test(time). Used to evaluate the ability of forehand moving shots.

7.2 1 minute backhand and forehand two steps moving (time). It is used to evaluate the conversion ability of forehand and backhand, and is widely used in table tennis skill tests.

7.3 30-second forehand two-point backspin shot (time). It is used to evaluate the ability of forehand moving and hitting power. The test requires the test subject to actively hit the ball with power, which is quite difficult.

7.4 30-second backhand block, pivot forehand attack, and crossover forehand attack sequence(time). Used to evaluate the overall movement and hitting ability of table tennis.

Data Collection

The data collection process in this study was conducted through the following steps:

1. This study will systematically investigate the relationship between SPARQ training programs and table tennis performance through a literature review approach. Based on comprehensive analysis of relevant literature covering SPARQ training systems, table tennis-specific physical conditioning, and technical characteristics, researchers will design questionnaires targeting table tennis coaches and male collegiate

athletes to identify current challenges and developmental bottlenecks in practical training practices.

2. The study will conduct on-site questionnaires with 120 male university student table tennis players and interview 18 table tennis instructors from five universities in Jiangsu Province. Through these methods, we aim to understand the current physical fitness and technical proficiency of university student athletes, while analyzing existing issues in their development.

3. Seven experts will be invited for face-to-face interviews. The goal is to develop a problem framework for focus group discussions and drafting components of a specific training program designed to enhance the physical fitness and table tennis skills of university students.

4. The research will organize a focus group discussion of 12 experts to develop a special training program to improve the physical fitness and technical ability of university table tennis players.

5. This study will carry out a 12-week experiment to systematically evaluate the physical fitness and table tennis technical ability of subjects at three time points: before training, in the middle (week 6) and in the end (week 12).

5.1 The study will conduct a pre-test on 30 male university student table tennis players before the intervention training, including special physical fitness indicators and table tennis skill assessment.

5.2 After completing the pre-test, the study will launch a 12-week intervention program consisting of three weekly sessions of 60-minute training each. Participants will be randomly assigned to two groups: the experimental group (n=15 male university table tennis players) and the control group (n=15 male university table tennis players).

5.3 The experimental group will be trained using the SPARQ training program, with the following schedule: Monday (10:00AM-11:00 AM.), Wednesday (3:00PM-4:00PM) and Friday (10:00AM-11:00 AM).

5.4 The control group will be trained using the traditional training schedule, which is as follows: Monday (3:00PM-4:00 PM), Wednesday (10:00AM-11:00 AM) and Friday (3:00PM-4:00 PM).

5.5 After six weeks of intervention training, the study will conduct a mid-term effectiveness evaluation to assess the efficacy of the SPARQ training program. The assessment will include specialized physical fitness indicators and table tennis skills tests, aiming to evaluate the improvement in physical conditioning and technical proficiency among male university student table tennis players.

5.6 After completing the 12-week intervention training, the study will conduct a final test through specialized physical fitness and table tennis skill assessments to comprehensively evaluate the overall effectiveness of the SPARQ training program. Subsequently, systematic analysis and comparative research will be performed on experimental data to thoroughly explore the mechanisms by which SPARQ training enhances athletic performance among university table tennis players.

Data Analysis

This study was mainly carried out using data analysis software, and the following methods were adopted:

1. Descriptive statistical analysis: The questionnaire data of male university students and table tennis coaches were statistically described in the form of mean ($\overline{x}$) ± standard deviation (SD).

2. Qualitative analysis: adopt the content analysis method to systematically analyze and discuss the text data of expert interview, focus group discussion and expert evaluation seminar.

3. Statistical analysis method: The independent sample t-test was used to compare the pre-test and post-intervention test results between the experimental group and the control group.

4. One-way repeated measurement analysis of variance (ANOVA) combined with Bonferroni post-test was used to conduct longitudinal comparative analysis of the test results of the experimental group at three time points: baseline (before training), mid-term (after 6 weeks of training) and final (after 12 weeks of training).

5. Content validity test: The item-objective consistency index (IOC) was used to evaluate the content validity of the questionnaire for male university students table tennis players, the questionnaire for table tennis coaches and the outline of expert interview. The IOC value of each item should be within the acceptable range of 0.60-1.00.

6. The questionnaire data of male university students who played table tennis were quantitatively analyzed using Likert scale (supplementary items should be selected according to the actual situation), and the average score of each measurement dimension was calculated to evaluate the feedback results of subjects.

Results

Drawing on the expertise of 12 specialists from table tennis coaching, academia, and education, we have developed a 12-week SPARQ training program specifically designed for university student table tennis players. The program details are as follows.

Table 1 SPARQ Training Program Outline

Variable	Phase 1 (1-2 weeks)	Intensity	Phase 2 (3-6 weeks)	Intensity	Phase 3 (Weeks 7-12)	Intensity
Speed	15-meter shuttle sprint	Group 4	15-meter shuttle sprint	Group 4	20-meter shuttle sprint	Group 4
	20-meter dash	Group 4	20-meter dash	Group 4	30-meter dash	Group 4
Strength	Weighted Squat	40 kg/8 times × 2 sets	Weighted Squat	50 kg/8 times × 2 sets	Weighted Squat	50 kg/8 times × 4 sets
	Weighted half squat	50 kg/6 times × 2 sets	Weighted half squat	60 kg/6 times × 2 sets	Weighted half squat	60 kg/6 times × 4 sets

Variable	Phase 1 (1-2 weeks)	Intensity	Phase 2 (3-6 weeks)	Intensity	Phase 3 (Weeks 7-12)	Intensity
Agility	The "rice" character running	Group 2	The "rice" character running	Group 2	The "rice" character running	Group 4
	3.5 meters to move	30 seconds × 2 sets	3.5 meters to move	30 seconds × 4 sets	4 meters to move	30 seconds × 4 sets
Reaction	10-meter dash on command	Group 4	15-meter dash on command	Group 4	20-meter dash on command	Group 4
	Reaction ball exercise	30 seconds × 2 sets	Reaction ball exercise	30 seconds × 4 sets	Reaction ball exercise	45 seconds × 4 sets
Quickness	transverse movement of resistance band	6 meters × 2 sets	transverse movement of	8 meters × 2 sets	transverse movement of	10 meters × 2 sets
	Resistance band running	10 meters × 2 sets	Resistance band running	15 meters × 2 sets	Resistance band running	20 meters × 2 sets

Table 1 presents a 12-week SPARQ training program designed based on focus group discussions and expert input.

Table 2 Comparative analysis of pre-test results of physical fitness indicators between experimental group and control group

Variable	Index	Experimental Group		Control Group		t	p
		$\bar{x}$	SD	$\bar{x}$	SD		
Speed	30m sprint test (seconds)	4.48	0.15	4.47	0.18	0.20	0.84
	3.5m lateral movement test (second)	4.60	0.15	4.58	0.16	0.38	0.71
Power	Continuous jump test (time)	45.60	2.32	45.27	2.31	0.39	0.70
	Rotational burst force test (meter)	7.15	0.20	7.17	0.17	-0.28	0.78
Agility	T-type run test(seconds)	11.00	0.18	11.03	0.16	-0.42	0.68
	Pro sensitive run test (seconds)	4.98	0.13	4.99	0.14	-0.24	0.81

Variable	Index	Experimental Group		Control Group		t	p
		$\bar{x}$	SD	$\bar{x}$	SD		
Reaction	Reaction ball test(time)	16.33	1.72	16.40	1.88	-0.11	0.92
	Light-hand reaction time test (millisecond)	419.33	16.84	420.67	15.61	-0.23	0.82
Quickness	Two points touching the table test (time)	44.47	1.19	44.20	1.78	0.52	0.61
	Running in a "rice" shape test (seconds)	18.52	0.16	18.44	0.18	1.36	0.19

*p<0.05

As shown in table 2, the independent samples t-test results for 10 physical fitness indicators revealed that all p-values were greater than 0.05 (ranging from 0.19 to 0.92). This indicates that prior to the initiation of the 12-week SPARQ training intervention, there were no statistically significant differences between the experimental group and the control group in all measured physical fitness indicators.

Table 3 Comparative analysis of pre-test results of physical fitness indicators between experimental group and control group

Test Category	Index	Experimental Group		Control Group		t	p
		$\bar{x}$	SD	$\bar{x}$	SD		
Speed	30m sprint test (seconds)	4.08	0.19	4.33	0.16	-4.12	0.00*
	3.5m lateral movement test (second)	4.20	0.10	4.41	0.15	-4.47	0.00*
Power	Continuous jump test (time)	49.47	1.88	46.93	2.02	3.52	0.00*
	Rotational burst force test (meter)	7.51	0.19	7.33	0.12	3.22	0.00*
Agile	T-type run test(seconds)	10.69	0.17	10.88	0.14	-3.32	0.00*
	Pro sensitive run test (seconds)	4.66	0.16	4.87	0.17	-3.30	0.00*
Reaction	Reaction ball test(time)	19.93	1.53	18.80	1.74	1.92	0.07
	Light-hand reaction time test (millisecond)	398.67	11.60	406.00	11.18	-1.77	0.09
Quick	Two points touching the table test (time)	48.20	0.94	46.67	1.59	3.25	0.00*
	Running in a "rice" shape test (seconds)	18.10	0.12	18.25	0.17	-2.91	0.01*

*p<0.05

As shown in table 3, among the 10 test indicators, the experimental group significantly outperformed the control group in 8 indicators ($p < 0.05$), namely 30-meter sprint ($p<0.05$), 3.5-meter agility run ($p<0.05$), platform jump ($p<0.05$), rotational explosive power ($p<0.05$), T-type run ($p<0.05$), pro-sensitivity run ($p<0.05$), two-point touch platform ($p<0.05$), cross-step run ($p<0.05$). There was no significant difference in the reaction ball test ($p=0.07$) and light-hand reaction time ($p=0.09$). Therefore, except for the reaction ball test and light-hand reaction time, all other indicators in the experimental group were significantly superior to those in the control group ($p<0.05$).

Table 4 Comparative analysis of pre-test results of table tennis skills between experimental group and control group

Index	Experimental Group		Control Group		t	p
	$\bar{x}$	SD	$\bar{x}$	SD		
One-minute forehand two-point rally test (time)	33.00	1.41	32.67	1.11	0.71	0.48
1 minute backhand and forehand two steps moving (time)	32.13	1.30	32.20	1.08	0.16	0.87
30-second forehand two-point backspin shot (time)	14.13	1.13	13.93	1.44	0.44	0.67
30-second backhand block, pivot forehand attack, and crossover forehand attack sequence (time)	5.33	0.90	5.40	1.06	0.19	0.84

*p<0.05

As shown in table 4, the independent samples t-test results of the four table tennis skills revealed that all p-values were significantly greater than 0.05 (ranging from 0.48 to 0.87). This indicates that prior to the initiation of the 12-week SPARQ training intervention, there were no statistically significant differences between the experimental group and the control group in all measured table tennis skills.

Table 5 Comparative analysis of post-test results of table tennis skills between experimental group and control group

Index	Experimental Group		Control Group		t	p
	$\bar{x}$	SD	$\bar{x}$	SD		
One-minute forehand two-point rally test(time)	37.73	1.10	34.53	1.19	7.81	0.00*
1 minute backhand and forehand two steps moving (time)	37.27	1.03	34.20	0.94	8.73	0.00*

Index	Experimental Group		Control Group		t	p
	$\bar{x}$	SD	$\bar{x}$	SD		
30-second forehand two-point backspin shot (time)	17.87	0.99	15.47	1.13	6.37	0.00*
30-second backhand block, pivot forehand attack, and crossover forehand attack sequence(time)	7.73	0.88	6.47	0.92	3.94	0.00*

*p<0.05

As shown in table 5, the experimental group significantly outperformed the control group in all four table tennis skill tests (all p-values <0.05). These indicating that 12 weeks of SPARQ training significantly improved the table tennis skills proficiency of the experimental group.

Discussion

This study systematically evaluated the efficacy of a 12-week SPARQ training program in enhancing specialized physical fitness and technical performance among university table tennis athletes. Results demonstrated that the experimental group significantly outperformed the control group in multiple physical fitness metrics, including speed, strength, agility, reaction time, and rapid acceleration. The experimental group also showed marked superiority in specialized skills tests such as two-point forehand attacks, left push right attack, underspin loops, and combined techniques. These findings further validate the positive and quantifiable impact of specialized, structured physical training on improving competitive performance in university table tennis athletes. The study also provides a practical solution to the prevalent issue of "overemphasizing technique while neglecting physical conditioning" in current university table tennis training programs.

First, the findings of this study align with recent research conclusions by multiple scholars on the impact of physical training on table tennis performance. Chen (2024) explicitly stated in his research that table tennis has entered the "big ball era," characterized by faster match rhythms and more rallies, which imposes higher demands on athletes 'speed, strength, multidirectional movement, and fatigue tolerance. Traditional single-technique training models struggle to meet modern competitive requirements. The SPARQ training program designed in this study systematically integrates multidimensional qualities such as speed, explosive power, agility, and reaction time. Its training effects are intuitively demonstrated through significant improvements in metrics like the 30-meter sprint, jump platform, and T-jump. These results are highly consistent with Chen's (2025) experimental findings on "agility and movement efficiency training for young table tennis players." Chen (2025)posited that targeted footwork and reaction training can effectively shorten athletes' judgment-to-start time. The positive outcomes in this study regarding the "3.5-meter movement" and "reaction ball test" strongly support this perspective.

Secondly, regarding power development particularly rotational explosive strength our findings align with Wang's (2021) research. Wang (2021) emphasized that the essence of table tennis stroke quality lies in efficient kinetic chain transmission, especially the coordinated force application between lower limb propulsion and torso rotation. Through exercises like weighted squats and medicine ball rotational throws, this study significantly enhanced the experimental group's rotational explosive power. This improvement directly correlates with enhanced technical execution of full-body-strength-demanding actions like forehand topspin shots. Wu (2022) also highlighted in her meta-analysis on "functional strength training's impact on table tennis players' stroke speed" that lower limb and core strength enhancement is a key factor in improving final ball speed, with our results providing further empirical support.

Furthermore, the three-phase cyclical design of "adaptation-consolidation-improvement" adopted in this study's training system embodies the scientific concept of progressive training load combined with specialized transformation. Specifically, this periodization strategy ensures that university athletes first establish a solid general physical foundation before gradually transitioning toward specialized explosive power and match-specific endurance. In the later phase of the experiment (Weeks 7–12), this study prioritized developing maximum power and fatigue resistance while simulating match intensity. The experimental group demonstrated continuous progress across all metrics without reaching a plateau, validating the effectiveness of this cyclical division logic. This outcome is further supported by Palmizal (2026), who highlighted in "training load monitoring for university athletes" that well-structured cycles paired with planned load-reduction weeks facilitate supercompensation and prevent overtraining. Incorporating these periodization principles into our protocol design likely contributed significantly to the low injury rate and high compliance observed in the experimental group.

Finally, this study also reveals common challenges in implementing systematic physical training within current university environments, such as fragmented training schedules, limited equipment, and prominent conflicts between academic and athletic demands. These issues align closely with the findings from Medvedev's (2022) nationwide survey on "Training Support for University Sports Teams under the Integration of Physical Education and Academic Education." Medvedev (2022) emphasizes that advancing scientific training requires not only advanced training protocols but also systematic support in management mechanisms, resource allocation, and coach training. By developing simplified action libraries and providing integrated lesson planning examples, this study aims to enhance the practicality of training programs under real-world conditions. This approach resonates with Forneris's (2013) advocacy for "localized adaptation of training programs based on institutional realities."

In conclusion, this study not only validates the efficacy of the SPARQ training protocol, but also establishes a multi-level dialogue between its design rationale and implementation process with cutting-edge domestic research and practical concerns in this field. It provides a model with both theoretical foundation and practical reference value for promoting scientific and specialized table tennis physical training in higher education institutions.

Conclusion and Suggestion

The study results demonstrated that the experimental group exhibited significantly superior performance compared to the control group in nine physical fitness indicators (excluding light-hand reaction) and all table tennis skill metrics ($p<0.05$), indicating that the SPARQ training program effectively enhances college students' physical fitness levels and specialized table tennis skills. Regarding the two findings—no significant improvement in reaction time and varying improvement magnitudes across different variables—the following discussion is provided.

Although the light-hand reaction time showed an improvement trend (419.33 ms ⟶ 398.67 ms), the difference was not statistically significant ($p=0.09$). Three factors contributed to this finding: First, the neural adaptation cycle is relatively long, and the 12-week intervention may have insufficient impact on reaction time, an indicator that reflects innate neural conduction velocity. Second, the training content was mismatched with the testing tasks, as the SPARQ protocol emphasizes complex responses while the light-hand reaction time test focuses on simple responses, resulting in limited transferability. Third, the baseline level was relatively high (419.33 ms), limiting the potential for further improvement.

There were significant variations in the improvement rates across physical performance indicators. For instance, continuous jumping (lower limb explosive power) showed an 8.5% increase, while T-jump running (directional agility) only improved by 2.8%. Key factors include: strength training loads being higher than agility training; lower baseline performance in continuous jumping (45.60 jumps), indicating greater potential for improvement (Chen, 2025) explosive power gains relying on neural adaptation with rapid initial progress, whereas agility improvements require movement pattern remodeling and a slower process; additionally, different tests exhibit varying sensitivity to training effects. Future research could focus on designing specialized reinforcement modules targeting indicators with lower improvement rates.

Recommendations from the Research Findings

1. The current SPARQ training program could incorporate more compound exercises integrating table tennis-specific movements, such as racket-hand response drills with footwork and multi-ball interval cycles simulating match rhythms, to enhance training transfer efficiency.

2. In training, simple monitoring methods such as morning pulse and RPE, along with video feedback, can be introduced to establish a "evaluation-adjustment-re-evaluation" cycle, enabling personalized regulation of load and content.

3. The training program should provide active recovery guidance such as stretching and foam rolling, and collaborate with the school health department to offer basic nutritional recommendations to alleviate insufficient fatigue recovery in student-athletes.

4. It is recommended to incorporate SPARQ training program into the curriculum or club credit system, and to provide athletes with flexible scheduling arrangements, thereby institutionalizing the resolution of the conflict between training and academic studies, and promoting a balance between training and

education.

5.This study has the following limitations: The sample consisted of only 30 male college students from five universities in Suzhou, resulting in a small sample size and exclusion of female participants, which limits the generalizability of findings; the 12-week intervention period may be insufficient for measuring neuroadaptive indicators such as reaction time; physiological and biochemical markers were not introduced to quantify training load; and the experimental environment differed from real training and competition settings. Future research could focus on the following directions: incorporating specialized table tennis compound training to enhance transfer efficiency; developing personalized regulation mechanisms using morning pulse monitoring, RPE assessment, and video feedback; providing active recovery guidance and basic nutritional recommendations; and integrating SPARQ training into curricula or credit systems to balance training and academic performance.

Recommendations for Future Research

1. Future studies could incorporate college student-athletes with diverse genders and training backgrounds for long-term tracking, to evaluate the sustainability and generalizability of SPARQ training program effects.

2. The combination of electromyography and motion capture can be used to analyze the mechanism of the effects of SPARQ training program on the action pattern, power efficiency and energy metabolism of table tennis, which can provide theoretical basis for optimizing training.

3. It is recommended to develop an SPARQ training program based on APP or wearable devices, integrating functions such as plan push, action demonstration, load monitoring, and feedback, to enhance the scientific rigor and accessibility of training.

4. Encourage multidisciplinary collaboration to explore the comprehensive effects of SPARQ training program on psychological resilience, decision-making ability, and injury prevention, and establish a comprehensive training evaluation system.

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