European Journal of Physical Education and Sport Science
ISSN: 2501 - 1235
ISSN-L: 2501 - 1235
Available on-line at: www.oapub.org/edu

DOI: 10.46827/ejpe.v13i2.6564 Volume 13 | Issue 2 | 2026

SELECTION AND APPLICATION OF SPORT-SPECIFIC PHYSICAL FITNESS EXERCISES FOR MALE STUDENT TABLE TENNIS ATHLETES AT DANANG SPORTS UNIVERSITY, VIETNAM

Nguyen Ngoc Tuan[1],
Tran Manh Hung[2i]
Danang Sport University,
Vietnam

Abstract:
This study aimed to develop and implement a system of sport-specific physical fitness exercises for male student table tennis athletes at Danang Sports University, Vietnam. In response to the increasing physical demands of modern table tennis, the research addresses the need for athletes to develop superior conditioning to effectively execute complex technical and tactical skills during high-intensity competition. The study focused on key physical components that directly influence performance, including movement speed, speed-strength, speed endurance, motor coordination, flexibility, and agility. A multi-method approach was employed, incorporating documentary analysis, pedagogical observation, expert interviews, pedagogical testing, and a training experiment. Twelve male student-athletes were randomly assigned to either an experimental or a control group. Sport-specific fitness was assessed using four validated tests: a diagonal ball-collection test, a weighted racket (0.5 kg) forehand-backhand coordination test, a two-minute single-rope skipping test, and a push-up test. The experimental training program, grounded in the principles of specificity, progressive overload, and systematic organization, was conducted over 12 weeks with two sessions per week. Results indicated that the exercise system significantly improved sport-specific physical fitness in the experimental group compared to the control group, with notable gains in speed-strength, motor coordination, and speed endurance. These findings highlight the importance of designing training exercises that closely mirror the specific movement patterns and physiological requirements of the sport. This study provides both theoretical and practical foundations for table tennis training and pedagogy at the university level, offering an applicable exercise system aimed at optimizing training effectiveness and enhancing the competitive performance of student-athletes.

Keywords: table tennis, sport-specific physical fitness, physical training exercises, student-athletes, sports training

[i] Correspondence: email hungcovua@gmail.com

1. Introduction

Table tennis is a high-intensity, fast-paced racket sport characterized by continuous explosive movements, precise ball control, and seamless technical–tactical coordination within extremely brief time intervals. The evolution of modern table tennis has led to a significant increase in rally speed and overall competitive intensity. Consequently, achieving elite performance now requires not only sophisticated technical skills but also a robust foundation of sport-specific physical fitness. In practice, such specialized conditioning is crucial for executing skills effectively, maintaining performance under fatigue, and attaining competitive success.

For student-athletes specializing in table tennis at sports universities, developing a scientifically based, sport-specific physical training regimen is essential for their holistic education and athletic development. However, empirical observation of current training practices reveals that physical conditioning programs for these athletes often remain generic, failing to adequately align with the unique kinematic and physiological demands of table tennis. Moreover, the selection and application of conditioning exercises frequently lack empirical grounding and insufficiently adhere to the principles of systematic progression, specificity, and continuity—each of which is vital for optimal adaptation.

To address this gap, research that systematically selects and applies sport-specific physical fitness exercises to enhance training efficacy is both timely and valuable, offering substantial scientific and practical contributions. Accordingly, this study aims to

1) identify and select a system of sport-specific physical training exercises, and
2) evaluate their effectiveness for male student table tennis athletes at Danang Sports University, Vietnam.

The findings are intended to contribute to improving the quality of athlete training and education within the university sports context.

2. Methods

To address the research objectives, this study employed a combination of established research methods commonly used in sports training research. This multi-method approach was designed to ensure the scientific validity, objectivity, and reliability of the findings.

2.1. Document Analysis and Synthesis

A comprehensive review and synthesis of domestic and international scientific literature was conducted. The analysis focused on literature related to the movement characteristics of table tennis, the sport's specific physical fitness requirements, and principles for developing specialized physical training exercises. The insights derived from this review established the theoretical framework for identifying key fitness components and subsequently guided the selection of appropriate training exercises for the participants.

2.2. Expert Interviews

Structured interviews were conducted with experienced table tennis specialists, including university lecturers and certified coaches. The primary aims were: (i) to identify a pool of suitable sport-specific physical training exercises, and (ii) to determine an appropriate battery of tests for evaluating sport-specific fitness. The interview protocol focused on assessing the relevance, effectiveness, and practical applicability of the proposed exercises and assessment procedures. A total of 20 experts participated in the interview process, providing consensus-based validation for the subsequent selection of exercises and tests.

2.3. Pedagogical Observation

Systematic pedagogical observation was implemented to monitor the training process. This involved recording detailed movement characteristics, evaluating participant engagement levels, and tracking performance progression throughout the experimental period. This method provided qualitative data to assess the appropriateness and practical feasibility of the implemented training program.

2.4. Pedagogical Testing

Sport-specific physical fitness was assessed using four selected tests, chosen for their demonstrated validity and reliability in evaluating table tennis athletes: (1) a lateral cross-step ball collection test (42 balls within 4m, measured in seconds); (2) a forehand and backhand coordination test using a 0.5 kg weighted racket for 20 seconds (measured in repetitions); (3) a two-minute single-rope skipping test (measured in repetitions); and (4) a push-up test (measured in repetitions). Detailed descriptions of each test protocol were provided to participants prior to assessment to ensure standardization.

2.5. Training Experiment

A 12-week experimental training intervention was conducted, with sessions held twice per week. The participants consisted of 12 male student table tennis athletes who were randomly assigned to either an experimental group (EG, n=6) or a control group (CG, n=6). The EG followed the newly developed sport-specific physical training program, while the CG adhered to the existing conventional training regimen. A pre-test/post-test design was used to compare results before and after the intervention to evaluate the program's effectiveness.

2.6. Statistical Analysis

Data were analyzed using both descriptive and inferential statistics. Descriptive statistics included the mean ($\bar{x}$) and standard deviation (SD). An independent samples t-test was used to identify statistically significant differences in performance changes between the EG and CG. The threshold for statistical significance was set at $p < .05$.

3. Results

3.1. Current Status of Sport-Specific Physical Fitness Training

3.1.1. Current Use of Sport-Specific Physical Training Exercises

To assess the current implementation of sport-specific physical fitness training for male student table tennis athletes at Danang Sports University, a survey combining systematic pedagogical observation with expert and coach interviews was conducted. The analysis aimed to determine the frequency, duration, and emphasis placed on specific conditioning exercises within regular training sessions.

Table 1: Current Use of Sport-Specific Physical Fitness Training Exercises (Based on Analysis of 10 Training Lesson Plans)

No.	Training Exercise	Total Training Time (minutes)	Frequency of Use (sessions)	Percentage of Total Training Time (%)
1	Lateral movement collecting 42 balls within a 4 m range	19	4	7.3
2	Forehand topspin using a 0.5 kg weighted racket	10	2	3.8
3	Backhand topspin using a 0.5 kg weighted racket	14	3	5.4
4	Movement drills with 1–2 kg sandbag resistance	11	3	4.2
5	Single lateral sliding step combined with attacking stroke	32	7	12.3
6	Single rope skipping for 2 minutes	35	8	13.5
7	Push-ups	14	6	5.4
8	Forehand topspin movement drills within half-table range	30	7	11.5
9	Backhand topspin movement drills within half-table range	35	5	13.5
10	Continuous drive strokes within half-table range	21	6	8.1
11	Backhand push combined with pivot forehand attack	15	7	5.8
12	Continuous drive strokes at a fixed position	24	6	9.2
Total		**260**		**100**

Note: Percentages were calculated based on the total duration of sport-specific physical fitness exercises across ten training sessions.

Table 1 summarizes the current application of sport-specific physical fitness exercises for male student table tennis athletes at Danang Sports University, based on an analysis of ten training lesson plans. The total time dedicated to this specific conditioning was 260 minutes.

The data indicate a clear emphasis on movement-based technical drills. Two-minute rope skipping and backhand topspin movement drills within the half-table range constituted the largest share of training time, each accounting for 13.5% of the total. This was followed by the single lateral sliding step combined with an attacking stroke (12.3%) and forehand topspin movement drills within the half-table range (11.5%).

In contrast, resistance and supplementary strength exercises were employed less frequently. Forehand topspin using a 0.5 kg weighted racket represented only 3.8% of the total training time, while movement drills with sandbag resistance and push-ups accounted for 4.2% and 5.4%, respectively.

In summary, the findings suggest that the current sport-specific physical training regimen focuses predominantly on movement and technical coordination. Resistance-based and supplementary conditioning exercises play a comparatively minor role in the existing training structure.

3.1.2. Selection of Sport-Specific Physical Fitness Tests

To identify appropriate assessment tools for evaluating sport-specific physical fitness in male student table tennis athletes, we conducted a comprehensive review of national and international scientific literature. This was complemented by structured consultations with experienced table tennis coaches, lecturers, and specialists to ensure the practical relevance and applicability of candidate tests.

Based on the literature review and preliminary screening, ten candidate tests were proposed. These were subsequently evaluated through a survey administered to 20 table tennis experts. The evaluation employed a priority-ranking scoring method, where:

- Priority 1 (highest suitability) was assigned 3 points,
- Priority 2 (moderate suitability) 2 points, and
- Priority 3 (lowest suitability) 1 point.

Table 2 presents the results of this expert evaluation.

Table 2: Expert Evaluation Results for Selecting Sport-Specific Physical Fitness Tests (n = 20)

No.	Test Content	Priority 1 (3 points)	Priority 2 (2 points)	Priority 3 (1 point)	Total Score
1	Single rope skipping for 2 minutes (repetitions)	17	1	2	55
2	Lateral cross-step movement collecting 42 balls within 4 m (seconds)	16	2	2	54
3	Forehand and backhand stroke coordination using 0.5 kg weighted racket for 20s (repetitions)	18	0	2	56
4	Ball dribbling run for 5 minutes	4	8	8	36
5	Push-ups (repetitions)	18	0	2	56
6	Shuttlecock throwing distance (meters)	6	4	10	36
7	Sprint and middle-distance	10	2	8	42

	running tests (30 m, 60 m, 400 m)				
8	Forehand topspin movement drills within half-table range (seconds)	10	3	7	42
9	Backhand topspin movement drills within two-thirds table range (seconds)	8	7	5	37
10	Full-table stroke coordination test (seconds)	11	0	0	33

Note: Priority 1 = 3 points; Priority 2 = 2 points; Priority 3 = 1 point.

The survey identified four tests that achieved the strongest consensus among experts, indicating superior practical relevance and specificity for assessing sport-specific physical fitness in table tennis. The forehand and backhand stroke coordination test using a 0.5 kg weighted racket and the push-up test obtained the highest total score (56 points each), underscoring their recognized relevance for evaluating upper-body explosive strength, movement speed, and coordination essential for table tennis.

The two-minute single-rope skipping test ranked second with 55 points, confirming its utility in assessing speed endurance, rhythmic capacity, and neuromuscular coordination. The lateral cross-step ball collection test within a 4 m range received 54 points and was highly rated for its capacity to reflect sport-specific footwork, agility, and movement coordination under simulated competitive conditions.

In contrast, more general physical fitness tests—including the ball dribbling run, shuttlecock throw for distance, sprint and middle-distance runs, and full-table stroke coordination test—received markedly lower scores. This pattern suggests their limited specificity and perceived lower relevance to the unique performance demands of table tennis.

Based on this expert consensus, the four top-rated tests were identified as possessing strong sport-specific characteristics, high practical feasibility, and demonstrable reliability for evaluating the physical fitness of student table tennis athletes. Consequently, these tests were selected for the subsequent assessment of participants and for application within the experimental phase of this study.

3.1.3. Reliability and Validity of the Selected Tests

To establish the scientific robustness of the assessment tools, we rigorously examined the reliability and validity of the four selected sport-specific physical fitness tests.

Table 3: Test–Retest Reliability of Sport-Specific Physical Fitness Tests (n = 12)

No.	Test Content	Test 1 (Mean ± SD)	Test 2 (Mean ± SD)	r	p
1	Lateral cross-step movement collecting 42 balls within 4 m (s)	36.25 ± 1.84	36.08 ± 1.76	0.88	< 0.01
2	Forehand and backhand coordination using 0.5 kg weighted racket for 20s (repetitions)	42.17 ± 2.31	42.58 ± 2.25	0.94	< 0.001

3	Single rope skipping for 2 minutes (repetitions)	182.75 ± 8.46	184.08 ± 7.95	0.82	< 0.05
4	Push-ups (repetitions)	45.33 ± 3.14	46.08 ± 3.02	0.86	< 0.01

Table 4: Summary of Reliability and Validity of Sport-Specific Physical Fitness Tests

No.	Test Content	Reliability (Test–Retest)	Validity (vs. Performance)	Evaluation
1	Lateral cross-step movement collecting 42 balls within 4 m (s)	0.88	0.85	Qualified
2	Forehand and backhand coordination using a 0.5 kg weighted racket for 20 s (repetitions)	0.94	0.93	Qualified
3	Single rope skipping for 2 minutes (repetitions)	0.82	0.81	Qualified
4	Push-ups (repetitions)	0.86	0.84	Qualified

All tests demonstrated high test–retest reliability, with correlation coefficients ranging from r = 0.82 to 0.94 ($p < .05$ for all). The forehand-backhand coordination test showed the highest reliability (r = .94), followed by the lateral cross-step (r = .88) and push-up tests (r = .86). The rope skipping test also exhibited good reliability (r = .82).

Validity coefficients, representing correlations with actual competitive performance, were similarly high (r = .81 to .93). The forehand-backhand coordination test again showed the strongest psychometric properties (r = .93). All coefficients exceeded the threshold of r = .80, confirming the tests' scientific robustness and practical utility for assessing sport-specific fitness in table tennis athletes.

3.1.4. Evaluation of the Current Sport-Specific Physical Fitness Status of Male Student Table Tennis Athletes

To establish a baseline, the sport-specific physical fitness level of all 12 male student table tennis athletes was assessed using the four selected tests. The results are presented in Table 5.

Table 5: Baseline Sport-Specific Physical Fitness Status (n = 12)

No.	Test Content	Mean ($\bar{X}$)	SD
1	Lateral ball collection movement 4 m × 42 balls (s)	130	4.54
2	Forehand-backhand coordination using 0.5 kg weighted racket for 20 s (repetitions)	29	1.27
3	Single rope skipping for 2 minutes (repetitions)	350	3.15
4	Push-ups (repetitions)	39	2.54

The results indicate a moderate level of sport-specific physical fitness among the athletes. The completion time for the lateral ball collection test suggests room for improvement in movement speed, agility, and sport-specific endurance. Similarly, scores from the

weighted racket coordination test reflect only moderate upper-limb speed-strength and technical coordination.

Performance on the rope-skipping and push-up tests further indicates that speed endurance and upper-body muscular strength have not yet reached optimal levels for high-intensity competition. Consultations with experts from other institutions confirmed that these metrics are relatively low compared to athletes of similar competitive levels.

Primary contributing factors include insufficient volume and intensity in sport-specific conditioning, lack of diversity in training content that reflects table tennis movement patterns, and limitations in training equipment and facilities. These findings highlight the need for a systematic, sport-specific training program to improve both physical conditioning and competitive performance.

3.1.5. Baseline Equivalence of the Experimental and Control Groups

To ensure valid post-intervention comparisons, we verified the initial homogeneity between the Experimental Group (EG) and Control Group (CG). Both groups were drawn from the same population and randomly assigned. A pre-test assessment using the four validated tests was conducted, with results shown in Table 6.

Table 6: Pre-Experimental Comparison of Sport-Specific Physical Fitness Between Groups (n=12)

No.	Test	Experimental Group (n=6)		Control Group (n=6)		t	p
		Mean	SD	Mean	SD		
1	4m lateral ball collection (s)	130	5.12	132	5.11	0.17	> .05
2	Weighted racket swings in 20s (reps)	30	2.14	32	2.05	1.02	> .05
3	2-minute rope skipping (reps)	350	4.15	348	4.27	0.25	> .05
4	Push-ups (reps)	43	2.25	45	2.34	0.85	> .05

No statistically significant differences were found between the EG and CG on any pre-test measures ($p > .05$), confirming baseline equivalence and satisfying a key precondition for attributing post-intervention differences to the experimental training program.

3.2. Development of the Exercise Selection Framework

3.2.1. Determination of Selection Principles

To establish a systematic framework for selecting sport-specific physical fitness exercises, this study was grounded in established sports training theory, the psychophysiological profiles of the athletes, and the targeted objectives of sport-specific physical development.

Through analysis of scientific literature, the kinematic demands of table tennis, and practical coaching requirements, four guiding principles for exercise selection were formulated:

- **Principle of Resistance and Modality:** Exercises should utilize appropriate external resistance, prioritize short-duration execution with moderate repetitions, and integrate high-resistance movements with bodyweight exercises to optimize training adaptations.
- **Principle of Muscular Specificity:** Selected exercises must specifically target the development of muscle groups essential for executing key table tennis techniques (e.g., footwork, topspin strokes, drives).
- **Principle of Individual and Contextual Suitability:** Exercise selection must align with the athletes' psychophysiological characteristics and be feasible within the constraints of the available training facilities.
- **Principle of Appropriate Load:** Prescribed exercise intensity and training volume must be commensurate with the athletes' performance level and individual characteristics.

To validate the relevance and applicability of these principles, structured interviews were conducted with 20 table tennis experts (lecturers and experienced coaches). The experts evaluated each principle using a priority-ranking system. The results, presented in Table 7, demonstrate strong consensus.

Table 7: Expert Evaluation of Exercise Selection Principles (n = 20)

No.	Principle	Priority 1 (3 pts)	Priority 2 (2 pts)	Priority 3 (1 pt)	Total Score
1	Principle of Resistance and Modality	18	2	0	58
2	Principle of Muscular Specificity	17	3	0	57
3	Principle of Individual and Contextual Suitability	19	1	0	59
4	Principle of Appropriate Load	19	1	0	59

Note: Maximum possible score = 60 points (20 experts × 3 points).

The total scores ranged from 57 to 59 out of 60 possible points, corresponding to approval ratings between 95.0% and 98.3%. This strong expert consensus affirms both the scientific grounding and practical utility of the proposed principles for guiding the subsequent selection of exercises.

3.2.2. Selection of Exercises Based on Expert Evaluation

Building upon the established selection principles and informed by a comprehensive analysis of professional literature, table tennis training curricula, and observed training practices, an initial pool of 35 candidate exercises was compiled. These exercises were categorized into two groups: those performed without equipment and those utilizing supplementary equipment (sandbags, weighted rackets).

To evaluate their suitability, a structured interview was conducted with 20 table tennis experts and coaches. Each exercise was rated using a three-level priority scoring

system (Priority 1 = 3 points, Priority 2 = 2 points, Priority 3 = 1 point). The consolidated results are presented in Table 8.

Table 8: Expert Evaluation of Candidate Sport-Specific Physical Fitness Exercises (n = 20)

No.	Exercise Content	Total Score
(A) Exercises Without Equipment		
1	Lateral movement combined with forehand topspin	44
2	Lateral movement combined with backhand topspin	44
3	Continuous forehand attacking	46
4	Continuous loop shots	45
5	Continuous high ball smashing	47
6	Backhand push combined with forehand topspin	48
7	Short push combined with movement and attacking	48
8	Continuous two-point drive shots	48
(B) Exercises Using Supplementary Equipment		
9	Wearing sandbags combined with side-to-side stepping and topspin strokes	55
10	Wearing sandbags combined with lateral movement coordination	54
11	Using a weighted racket for bilateral topspin coordination	55
12	Using a weighted racket combined with step movement and technical execution	55
13	Using a weighted racket for multi-point drive shots	54
14	Using a weighted racket for backhand push combined with attacking	57
15	Using a weighted racket combined with diagonal stepping for long-distance attacking	56
16	Using a weighted racket for forehand topspin along two straight-line directions	56
17	Using a weighted racket for wrist shaking combined with serving techniques	58

The evaluation revealed that numerous exercises attained high scores, indicating strong expert consensus on their suitability. The selected exercises are primarily oriented toward developing movement speed, speed-strength, speed endurance, and sport-specific coordination—key physical attributes for competitive performance.

The final curated exercise system demonstrates alignment with the principles of specificity and scientific validity while maintaining high practical feasibility within typical training environments. This validated system established the foundation for designing the subsequent experimental training program.

3.2.3. Experimental Training Program

3.2.2.1. Guiding Principles

The experimental training program was constructed by synthesizing findings from the training assessment, validated exercise selection, and established evaluation tests. Its development followed these foundational principles:

- **Scientific Validity & Appropriateness:** Grounded in exercise science and tailored to participants' physiological profiles and baseline levels.
- **Specificity:** Targeting physical capacities critical to table tennis: movement speed, speed-strength, sport-specific endurance, and motor coordination.

- **Systematic Progression & Continuity:** Structured to facilitate systematic overload, with volume and intensity progressing gradually over the intervention.
- **Practical Applicability:** Feasible within available facilities and integrable into the existing training schedule.
- **Safety & Efficacy:** Prioritizing athlete safety while maximizing training effectiveness.

3.2.3.2. Program Content and Structure

The program integrated the expert-validated exercises, organized to target key fitness domains: movement speed/agility, sport-specific strength (speed-strength), sport-specific endurance, and integrated technical-physical conditioning. The specific exercises are detailed in Table 9.

Table 9: Exercises Comprising the Experimental Training Program

No.	Exercise Content	Development Purpose
1	Diagonal stepping movement while collecting 42 balls over 4 m	Develop movement speed and sport-specific endurance
2	Forehand topspin using a 0.5 kg weighted racket	Develop forehand speed-strength
3	Backhand topspin using a 0.5 kg weighted racket	Develop backhand speed-strength
4	Wearing 1–2 kg sandbags while performing movement drills	Improve lower-limb strength and balance ability
5	Lateral sliding movement combined with topspin strokes	Develop technical coordination and movement speed
6	Single rope skipping for 2 minutes	Develop general endurance and foot speed
7	Push-up exercise	Develop upper-body strength
8	Movement combined with forehand topspin within half table area	Improve power and technical accuracy
9	Movement combined with backhand topspin within half table area	Improve backhand power and technique
10	Movement combined with drive shots within half table area	Develop reaction speed and ball-handling ability
11	Backhand push combined with forehand attack	Develop movement coordination and tactical execution
12	Continuous drive shots at one point	Develop sport-specific endurance

3.2.3.3. Implementation Protocol

The program was implemented as a 12-week intervention with two sessions per week (100-120 minutes per session), integrated into the team's regular extracurricular schedule. Training load (volume and intensity) was systematically progressed based on session objectives and observed athlete adaptation, adhering to the principle of progressive overload.

3.2.3.4. Control Group Protocol

The control group (CG) continued their standard, conventionally structured sport-specific physical training regimen as part of the team's regular program, without the structured modifications applied to the experimental group.

3.2.4 Experimental Design and Implementation

3.2.4.1. Research Design and Participant Allocation

A controlled pedagogical experiment employing a parallel-group design was implemented, featuring an Experimental Group (EG) and a Control Group (CG). The participant sample comprised 12 male student-athletes from the university's table tennis team. To ensure baseline equivalence, participants were randomly assigned to either the EG (n=6) or CG (n=6).

3.2.4.2. Testing Procedures

- **Pre-test:** Before the intervention, all participants underwent a baseline assessment using the four validated sport-specific fitness tests.
- **Post-test:** Upon completion of the 12-week intervention, the same battery of tests was re-administered to all participants.

3.2.4.3. Intervention Protocol

The experimental intervention was conducted over 12 weeks (September to December 2006), with two sessions per week (Wednesdays and Saturdays), each lasting 100–120 minutes.

- **Experimental Group (EG):** Followed the newly developed, structured training protocol detailed in Section.
- **Control Group (CG):** Continued their standard, conventionally structured sport-specific physical training regimen as part of the team's regular program, without the structured modifications of the experimental protocol.

3.2.5 Baseline Assessment and Group Equivalence

Prior to the intervention, a pre-test assessment established baseline fitness levels and verified homogeneity between the two groups. As shown in Table 10, no statistically significant differences were found between the EG and CG on any of the pre-test measures ($p > .05$), confirming their initial equivalence.

Table 10: Pre-Experimental Comparison of Sport-Specific Physical Fitness

No.	Test	Experimental Group (n=6)	Control Group (n=6)	t	p
		Mean ± SD	Mean ± SD		
1	4m lateral ball collection (s)	130.0 ± 5.12	132.0 ± 5.11	0.17	> .05
2	Weighted racket swings in 20s (reps)	30.0 ± 2.14	32.0 ± 2.05	1.02	> .05
3	2-minute rope	350.0 ± 4.15	348.0 ± 4.27	0.25	> .05

	skipping (reps)				
4	Push-ups (reps)	43.0 ± 2.25	45.0 ± 2.34	0.85	> .05

3.2.6 Effects of the Training Intervention

3.2.6.1. Post-Intervention Comparison

Following the 12-week intervention, post-test results revealed marked improvements in the EG compared to the CG (Table 10). The EG's performance was significantly superior to the CG's on every test variable, with all between-group differences reaching statistical significance ($p < .05$).

Table 11. Post-Experimental Comparison of Sport-Specific Physical Fitness

No.	Test	Experimental Group (n=6)	Control Group (n=6)	t	p
		Mean ± SD	Mean ± SD		
1	4m lateral ball collection (s)	122.0 ± 3.24	128.0 ± 3.42	3.12	< .05
2	Weighted racket swings in 20s (reps)	38.0 ± 1.23	35.0 ± 1.27	3.32	< .05
3	2-minute rope skipping (reps)	370.0 ± 3.25	354.0 ± 3.95	2.75	< .05
4	Push-ups (reps)	54.0 ± 2.07	47.0 ± 2.11	2.78	< .05

3.2.6.2. Analysis of Performance Improvement

To quantify the magnitude of improvement, the relative rate of change (growth rate) was calculated for each group (Table 11). The EG demonstrated substantially greater improvement rates across all tests.

Table 12: Growth Rate of Sport-Specific Physical Fitness Following the Intervention

Test	Experimental Group (%)	Control Group (%)
Ball collection movement over 4 m × 42 balls	-6.35	-3.08
Weighted racket swing in 20 seconds	10.54	8.96
Rope skipping for 2 minutes	5.56	1.71
Push-ups	8.45	4.35

Note: A negative percentage for the ball collection test indicates improved performance (reduced time).

Test	Experimental Group (%)	Control Group (%)
Ball collection movement over 4 m × 42 balls	-6.35	-3.08
Weighted racket swing (0.5 kg) in 20 seconds	10.54	8.96
Rope skipping for 2 minutes	5.56	1.71
Push-ups	8.45	4.35

Note: A negative percentage for the ball collection test indicates improved performance (reduced time).

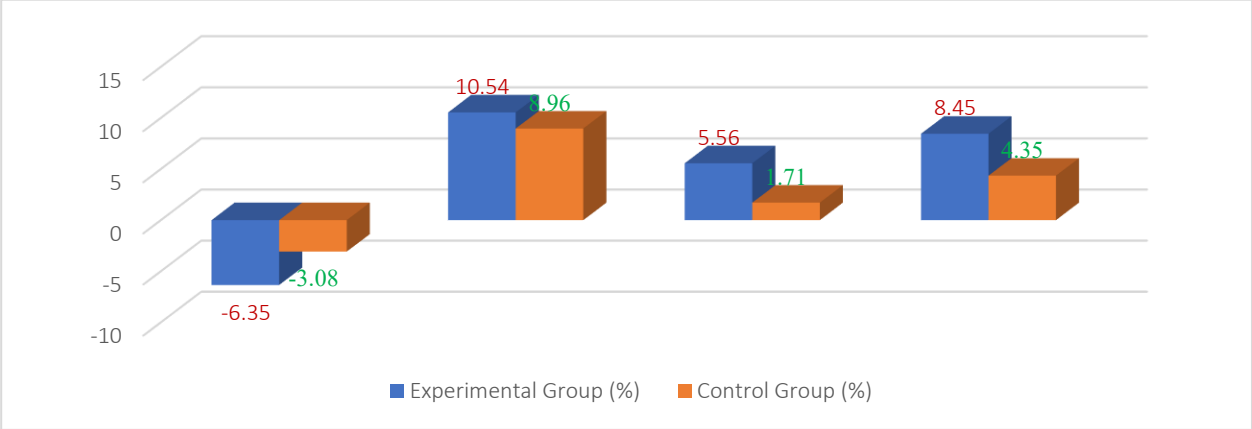

Figure 1: Comparison of Sport-Specific Physical Fitness Growth Rates Between the Experimental and Control Groups Following the Intervention

4. Discussion

The results of this study confirm the efficacy of a scientifically constructed, sport-specific physical training program in significantly improving key fitness attributes among male student table tennis athletes at Danang Sports University. The 12-week experimental intervention elicited statistically superior gains in the Experimental Group (EG) compared to the Control Group (CG) across all four validated assessment metrics (*p* < .05). This outcome underscores the critical role of targeted conditioning in bridging the gap between foundational athleticism and the specialized demands of high-level table tennis performance.

The most pronounced improvements were observed in domains central to competitive success: speed-strength and sport-specific movement proficiency, as measured by the 4m lateral ball collection test and the 20-second weighted racket coordination test. These enhancements align directly with the kinetic chain and bioenergetic profile of modern table tennis, a sport defined by explosive, multi-directional displacements, rapid stroke production, and sustained high-intensity efforts within short rallies (Lees, 2003; Zagatto, Kondrič, & Knechtle, 2023). The significant reduction in ball collection time indicates enhanced agility, reactive footwork, and anaerobic capacity—attributes essential for covering the table effectively. Concurrently, the increased repetitions in the weighted racket test suggest improved upper-limb speed-strength, neuromuscular coordination, and local muscular endurance, which are vital for maintaining stroke quality and power under fatigue.

The success of the intervention can be attributed to its firm grounding in the principle of specificity, a cornerstone of contemporary training theory (Bompa & Haff, 2009). Unlike the conventional regimen followed by the CG, which leaned heavily on generic movement drills, the experimental program was meticulously designed to overload physiological systems and movement patterns that directly mirror competitive actions. By integrating external resistance (e.g., weighted rackets, sandbags) into sport-

kinematic exercises, the program created a targeted stimulus for the development of elastic strength and power—qualities indispensable for the forceful and rapid strokes characteristic of modern play (Baechle & Earle, 2008). This approach ensures that fitness gains are not isolated but are functionally transferable to technical execution.

Furthermore, the findings resonate with emerging research highlighting the importance of integrated, context-conditioned training in racket sports. The exercise selection, which emphasized multi-directional agility, stroke coordination under load, and high-intensity intermittent endurance (e.g., 2-minute rope skipping), reflects the holistic physical demands identified in recent performance analyses (Kondrič, Zagatto, & Sekulić, 2013; Malagoli Lanzoni et al., 2014). This methodology likely fostered a concurrent development of physical capacities and technical-tactical acuity, as exercises simulated realistic match scenarios, thereby enhancing the athletes' decision-making and movement economy under pressure.

The superiority of the EG's outcomes over those of the CG also validates concerns raised in prior domestic research regarding the limitations of generic physical preparation in table tennis (Tran Duc Dung, 2001). The present study demonstrates that diversifying training content with scientifically selected, task-specific exercises leads to more significant and relevant adaptations. This evidence provides a pragmatic framework for coaches and trainers at sports universities to systematically upgrade their conditioning protocols, moving beyond a one-size-fits-all approach to one that is periodized, individualized, and explicitly aligned with the sport's unique energetics and biomechanics.

4.1 Limitations and Future Research

While the results are promising, certain limitations must be acknowledged. The study's sample size was relatively small (n=12), and the intervention duration was confined to 12 weeks. These factors may affect the generalizability of the findings and limit insights into long-term adaptation and performance retention. Future research should seek to replicate this investigation with larger, more diverse cohorts-including female athletes and different competitive levels—and employ longer intervention periods (e.g., 6-12 months) to examine sustained effects and potential periodization strategies. Additionally, incorporating direct performance outcome measures (e.g., match win rates, shot accuracy metrics) alongside fitness tests would provide a more comprehensive evaluation of the program's impact on competitive efficacy.

5. Conclusion

Based on the comprehensive analysis of the current status and experimental results, this study draws the following principal conclusions:

- **A Validated Assessment Tool:** The study selected and validated a battery of four sport-specific physical fitness tests (42-ball collection over 4m, 20-second weighted racket coordination, 2-minute single rope skipping, and push-ups), demonstrating

high reliability and strong correlations with competitive performance (r = .81 to .93). This establishes a practical and scientifically sound evaluation instrument.

- **Diagnosis of the Training Status:** The initial assessment revealed a deficit in the sport-specific physical fitness of the male student-athletes at Danang Sports University compared to the general standard for athletes at a similar competitive level. This gap was primarily attributed to insufficient diversity in training content, as well as inadequate volume and intensity in the existing conditioning exercises.
- **Development of an Exercise System:** Guided by established scientific principles, the study selected 13 highly specialized sport-specific physical exercises. This exercise system received strong endorsement from experts, confirming its scientific foundation and practical applicability.
- **Confirmation of Intervention Efficacy:** The results of the 12-week training experiment provided robust evidence for the effectiveness of the implemented sport-specific exercise system. The Experimental Group (EG) demonstrated superior improvement and significantly higher growth rates across all tests compared to the Control Group (CG), with all differences being statistically significant ($p < .05$).

In summary, this study confirms that the deliberate selection and application of a scientifically designed, sport-specific physical training system is instrumental in enhancing training effectiveness and building the essential physical foundation required for the competitive performance of male student table tennis athletes.

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Conflict of Interest Statement

The authors declare no conflicts of interest. This research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

About the Author(s)

Nguyen Ngoc Tuan (PhD), Senior Lecturer, Danang Sports University, Vietnam.

Tran Manh Hung (PhD), Head of Faculty of Sports Management, Danang Sports University, Vietnam.

ORCID: https://orcid.org/0009-0003-9229-2900

References

a. Vietnamese Sources

Bompa, T. O. (2003). Theory and Methodology of Modern Sports Training. National Sports Publishing House.

Duong, N. C. (2004). Sports Measurement. National Sports Publishing House.

Duong, N. C., Nguyen, K. M., & Nguyen, D. H. V. (2000). Exercise and Sport Physiology. National Sports Publishing House.

Le, B., & Nguyen, T. T. (1991). Theory and Methodology of Youth Sports. National Sports Publishing House.

Nguyen, T., & Pham, D. T. (2000). Theory and Methodology of Physical Education and Sports]. National Sports Publishing House.

Tran, D. D. (2001). Physical Conditioning in Sports]. National Sports Publishing House.

General Department of Sports and Physical Training. (2002). Table Tennis – Athlete Training Curriculum. National Sports Publishing House.

Vu, D. T. (2005). Scientific Research Methods in Physical Education and Sports. National Sports Publishing House.

b. International Sources

Baechle, T. R., & Earle, R. W. (2008). *Essentials of strength training and conditioning* (3rd ed.). Human Kinetics. Retrieved from https://www.researchgate.net/publication/298559447_Essentials_of_Strength_Training_and_Conditioning_3E

Bompa, T. O., & Haff, G. G. (2009). *Periodization: Theory and methodology of training* (5th ed.). Human Kinetics. Retrieved from https://books.google.ro/books/about/Periodization.html?id=pu96DwAAQBAJ&redir_esc=y

Elliott, B., Reid, M., & Crespo, M. (2009). *Technique development in racket sports*. ITF Ltd. Retrieved from https://www.researchgate.net/publication/274370971_Technique_Development_in_Tennis_Stroke_Production

Lees, A. (2003). Science and the major racket sports: A review. *Journal of Sports Sciences, 21*(9), 707–732. https://doi.org/10.1080/0264041031000140275

Malagoli Lanzoni, I., Di Michele, R., & Merni, F. (2014). A notational analysis of shot characteristics in top-level table tennis players. *European Journal of Sport Science, 14*(4), 309–317. https://doi.org/10.1080/17461391.2013.819382

Platonov, V. N. (1997). *General theory of athlete preparation in Olympic sports*. Olympic Literature.

Schmidt, R. A., & Lee, T. D. (2011). *Motor control and learning: A behavioral emphasis* (5th ed.). Human Kinetics. Retrieved from https://psycnet.apa.org/record/2011-15560-000