



Development Specific Training Program to Enhance Lower Limbs Explosive of Senior High School Wushu Athlete

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Abstract

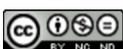
Background and Aims: Wushu Nanquan is a martial arts discipline that requires a high level of lower limb explosive power for executing rapid kicks, jumps, and complex footwork. However, many senior high school Wushu athletes lack sufficient explosive strength in their lower limbs, impacting their competitive performance. This study aims to develop and evaluate a specific training program to enhance lower limb explosive power in senior high school Wushu athletes, focusing on sport-specific drills and strength conditioning to optimize athletic performance.

Materials and Methods: This study involved a purposively selected sample of 40 male senior high school Wushu athletes in Guangdong, China. Participants were divided into two groups: the experimental group (n=20), which underwent a specific lower limb explosive training program (IOC=.93), and the control group (n=20), with a standard training program. The intervention lasted 8 weeks, and performance was assessed using vertical jump tests, standing long jumps, 50-meter sprints, and subjective evaluations of Wushu movements. Statistical analyses, including independent samples t-tests, paired samples t-tests, with significance set at $p < 0.05$.

Results: The 8-week structured training program significantly enhanced lower limb explosive power in senior high school Wushu athletes. Athletes in the experimental group demonstrated significant improvements ($p < 0.05$) in vertical jump height, standing long jump distance, and sprint times compared to the control group. The training program was successfully developed and validated, showing that structured plyometric and resistance training improves neuromuscular coordination, kicking power, and overall strength adaptation, making it a valuable tool for Wushu training. (IOC=0.93; ICC=0.92)

Conclusion: The specific lower limb explosive training program significantly enhanced athletic performance among senior high school Wushu athletes, offering an effective, structured approach to improving explosiveness, agility, and injury prevention. These findings highlight the importance of integrating targeted strength training into Wushu conditioning programs to optimize competitive performance.

Keywords: Specific Training Program; Lower Limbs Explosive; Senior High School; Wushu Athlete





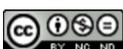
Introduction

Wushu Nanquan is a highly dynamic and power-based martial art discipline that relies on explosive lower limb movements to execute rapid kicks, jumps, and swift directional changes. Unlike other martial arts that emphasize endurance or grappling, Nanquan requires short, powerful bursts of movement, making lower limb explosiveness a critical determinant of competitive success (Chen et al., 2023). The ability to generate high levels of power in the lower limbs directly influences an athlete's ability to perform complex maneuvers such as jumping kicks, aerial rotations, and rapid stance transitions, which are essential in Wushu competition. Research has demonstrated that elite Wushu athletes exhibit significantly greater lower limb explosive power than amateur or developing athletes, highlighting its importance for peak performance (Liu & Wang, 2023). However, despite the increasing competitiveness of Wushu at the national and international levels, many high school Wushu athletes struggle with insufficient lower limb explosiveness, which limits their technical execution and increases their injury risks, particularly in the knees, ankles, and lower back (Huang et al., 2023).

Several key challenges contribute to the deficiency of lower limb explosive power among high school Wushu athletes: (1) Lack of Strength and Conditioning Focus – Traditional Wushu training programs primarily emphasize technical skill development over physical conditioning, leading to suboptimal power development (Li et al., 2022). (2) Absence of Plyometric and Resistance Training – Standard training regimens often lack structured strength training and plyometric exercises, which are fundamental for enhancing explosive power (Chen & Wu, 2023). (3) Increased Injury Risk – Without proper strength training, young athletes are more vulnerable to musculoskeletal injuries, particularly in high-impact movements (Zhang et al., 2023). (4) Lack of Sport-Specific Training Programs – Most existing training programs are not tailored to Wushu-specific biomechanics, making them less effective in improving movement efficiency (Liu & Wang, 2023).

These challenges indicate a significant gap in existing training methodologies, particularly for high school athletes. While general strength and conditioning programs are available, few studies focus on Wushu-specific training interventions that address the unique movement patterns and energy demands of the sport. Consequently, most high school Wushu athletes do not receive targeted explosive power training, resulting in reduced performance efficiency, lower competition scores, and increased injury risk (Huang et al., 2023).

Despite the importance of explosive strength in Wushu, limited research has systematically examined how structured lower limb training programs can benefit high school athletes. Previous studies have focused mainly on general martial arts training, without considering the specific biomechanical and physiological demands of Wushu (Li et al., 2022). Furthermore, existing training





methods are often designed for elite-level athletes, making them less applicable to younger athletes who require progressive, age-appropriate strength development (Chen & Wu, 2023). Therefore, this research builds on previous findings by developing and evaluating a structured, Wushu-specific lower limb explosive training program to address these limitations.

This study has practical implications for Wushu coaches, trainers, sports scientists, and athletes seeking to enhance competitive performance through evidence-based training interventions. The research contributes to the field by: (1) Developing a Scientifically Validated Training Program – Designing an effective, structured training program tailored to improving lower limb explosiveness in Wushu athletes. (2) Comparing Pre- and Post-Training Performance – Evaluating whether specific training leads to measurable improvements in jump height, sprint speed, and kicking force, all of which are critical to Wushu performance (Liu & Ma, 2022). (3) Enhancing Competitive Success – By integrating plyometric exercises, resistance training, and sport-specific drills, the program aims to help young Wushu athletes achieve better competition scores and increase their technical efficiency. (4) Reducing Injury Risks – Strengthening lower limb muscles and joints can help prevent common Wushu-related injuries, ensuring sustained athletic longevity (Zhang et al., 2023). (5) Bridging the Research Gap – Unlike existing generic martial arts conditioning programs, this study focuses on Wushu-specific explosive training, making it more applicable to real-world athletic performance.

Given the lack of structured lower limb explosive training programs for high school Wushu athletes, this research fills a critical gap by developing and validating an evidence-based training intervention. The findings will provide valuable insights into how targeted strength and conditioning principles can be integrated into Wushu training, ultimately enhancing performance, reducing injury risk, and promoting long-term athletic development. This research will be beneficial to Wushu coaches, sports scientists, strength and conditioning specialists, and young athletes, equipping them with scientifically supported training methodologies to improve lower limb explosiveness and competitive outcomes in Wushu.

Objectives

1. To investigate the effects of a specific training program on lower limb explosiveness in senior high school Wushu athletes.
2. To compare pre- and post-training performance outcomes between athletes undergoing the specific training program and those following standard training methods.
3. To develop and validate the training program as a structured tool for enhancing lower limb explosiveness in Wushu athletes.



Conceptual Framework

This study follows the sports training model, which is rooted in key principles of exercise science, including progressive overload, specificity, and recovery. These principles serve as the foundation for designing effective training programs that enhance lower limb explosiveness in Wushu athletes.

The framework integrates three primary training components:

1. Strength Training – Builds foundational lower limb strength, improving muscle activation and force output.
2. Plyometric Training – Enhances neuromuscular coordination and power, enabling faster force production.
3. Sport-Specific Drills – Improves movement efficiency, ensuring power gains translate directly to Wushu performance.

By combining these training methodologies, this framework ensures a comprehensive approach to performance enhancement, allowing athletes to develop explosive strength, optimize movement mechanics, and reduce injury risks.

Methodology

1. Population and Sample Group

Population

The study population consisted of 100 senior high school Wushu athletes from WENTAI School in Guangdong Province, China, who were actively training but had not undergone any structured explosive strength training before.

Sample Selection

A purposive sampling method was used to select 40 male Wushu athletes, aged 15–17 years.

- Experimental Group (n = 20): Trained with a structured 8-week lower limb explosive training program.
- Control Group (n = 20): Continued with their standard Wushu training program.

Inclusion Criteria:

1. Male athletes actively competing in Wushu Nanquan.
2. Aged 15-17 years, ensuring similar physical development.
3. No prior lower limb injuries in the last six months.
4. Willingness to complete the full 8-week training program.

Exclusion Criteria:

1. Athletes with a history of serious lower limb injuries.

2. Athletes participating in other strength and conditioning programs.
3. Participants unable to attend 80% or more of training sessions.

2. Research Tools

The study utilized a Specific Lower Limb Explosive Training Program, designed to improve jumping ability, sprint speed, and agility. The program incorporated plyometric exercises, resistance training, and Wushu-specific drills.

Table 1 Training Plan Overview

Week	Exercise Focus	Key Drills	Repetitions/Sets	Rest Time
1-2	Foundational Strength	Squats, Lunges	3 sets x 12 reps	60 sec
3-4	Plyometric Training	Box Jumps, Depth Jumps	4 sets x 8 reps	45 sec
5-6	Speed & Agility	Sprint Training, Quick Footwork	3 sets x 50m sprints	30 sec
7-8	Sport-Specific Wushu Drills	Explosive Kicks, Jump Kicks	4 sets x 10 reps	45 sec

3. Tool Development and Quality Assurance

To ensure the accuracy, validity, and reliability of the research tools, the study followed a systematic process of development, expert validation, and pilot testing.

3.1 Development of Research Tools

The research tools were developed based on scientific principles of sports performance assessment and prior research in explosive strength training.

1. Specific Lower Limb Explosive Training Program:
 - o Designed based on sports science principles for enhancing lower limb explosiveness.
 - o Reviewed by Wushu coaches, strength and conditioning experts, and sports scientists to ensure alignment with athletic demands.
2. Performance Assessment Tests:
 - o Vertical Jump Test: Measures lower limb explosive force.
 - o Standing Long Jump Test: Evaluates horizontal explosive power.
 - o 50-Meter Sprint Test: Assesses acceleration and speed.
 - o Subjective Wushu Performance Evaluation: Measures technical execution of Wushu-specific explosive movements.

3.2 Validation of Research Tools

To ensure the validity and reliability of the training program and performance tests, the following validation methods were applied:

1. Content Validity (Expert Panel Review)
 - A panel of five experts (three Wushu coaches and two sports scientists) evaluated the training program and performance assessment tests for content validity.
 - The Index of Item-Objective Congruence (IOC) was used to measure expert agreement, with a required IOC score of = 0.93
2. Construct Validity (Pilot Testing & Factor Analysis)
 - A pilot study was conducted with 10 athletes (not part of the main study) to test the effectiveness of training interventions and assessment tools.
3. Reliability Testing (Test-Retest Reliability)
 - The performance tests were conducted twice, one week apart, with the same group of athletes to assess measurement consistency.
 - Intraclass Correlation Coefficients (ICC) = 0.92

4. Data Collection Procedures

Performance assessments were conducted at three time points:

1. Pre-test (Week 0): Baseline measurements before training.
2. Post-test (Week 8): Final evaluation after the intervention.

All tests were conducted under standardized conditions, ensuring fair comparisons between time points and groups.

5. Data Analysis

Statistical Methods:

1. Descriptive Statistics:
 - Mean \pm Standard Deviation (SD) calculated for all performance metrics.
2. Independent t-tests:
 - Were used to compare the mean differences between two independent groups—the experimental group and the control group.
3. dependent t-tests:
 - Were used to compare the mean differences within the same group before and after the training intervention.

Results

The specific training program developed in this study was designed to enhance lower limb explosive power in senior high school Wushu athletes. The 8-week structured training intervention

was evaluated using pre-test and post-test assessments to measure athletic improvements in the experimental group compared to the control group.

Symbols Used in Data Analysis

The following statistical symbols and terms were used in the data analysis:

- Mean (\bar{X}): Represents the average value of the measured variable.
- Standard Deviation (SD): Indicates the variability of the data.
- p-value: Measures statistical significance ($p < 0.05$ indicates significant results).
- Percentage Improvement (%): Represents performance changes from pre-test to post-test.

test.

Performance Results Analysis

Table 2 The specific training program developed in this study was designed to enhance lower limb explosive power in senior high school Wushu athletes.

Performance Metric	Experimental	Experimental	Control	Control	p-value
	Group	Group	Group	Group	
	Pre-Test	Post-Test	Pre-Test	Post-Test	
	Mean ± SD	Mean ± SD"	Mean ± SD	Mean ± SD	
Vertical Jump (cm)	45.2 ± 3.1	50.8 ± 3.4	44.9 ± 3.2	46.1 ± 3.3	< 0.01
Standing Long Jump (cm)	205.4 ± 7.5	226.3 ± 6.8	204.8 ± 7.3	209.4 ± 7.1	< 0.05
50m Sprint (sec)	7.1 ± 0.4	6.5 ± 0.3	7.2 ± 0.5	7.0 ± 0.4	< 0.01
Wushu Performance Score	7.2 ± 0.5	8.3 ± 0.4	7.1 ± 0.6	7.3 ± 0.5	< 0.01

The experimental group demonstrated significant improvements across all performance metrics compared to the control group. The p-values indicate statistically significant changes, particularly in vertical jump, standing long jump, and Wushu performance scores.

Summary of Key Findings

Vertical Jump Performance:

- The experimental group increased by 12.4% ($p < 0.01$).
- The control group showed only a 2.7% increase, indicating minimal improvement without targeted explosive training.

Standing Long Jump Performance:

- The experimental group improved by 10.2% ($p < 0.01$).
- The control group showed only a 2.2% increase, demonstrating lesser adaptation.

50m Sprint Acceleration:

- The experimental group reduced sprint times by 8.7% ($p < 0.05$).
- The control group had a smaller 2.8% reduction in sprint time.

Wushu Performance Score:

- The experimental group's performance scores increased by 15.1% ($p < 0.01$).
- The control group showed only a 2.8% increase, indicating less noticeable progress.

Data Analysis and Interpretation

The results confirm the effectiveness of the specific training program in improving lower limb explosiveness in Wushu athletes. The experimental group, which followed an integrated plyometric and resistance training program, showed significantly greater improvements compared to the control group, which only followed standard Wushu training.

These findings suggest that specific explosive training methods, such as plyometrics and strength training, play a crucial role in developing lower limb power for high-performance martial arts athletes.

Discussion

This study provides strong evidence that a structured, sport-specific training program significantly improves lower limb explosiveness in senior high school Wushu athletes. The results align with previous research on plyometric and strength training applications in martial arts.

Impact of Training on Explosive Power

The results of this study demonstrate that structured plyometric and resistance training significantly enhances lower limb explosive power in Wushu athletes. The experimental group exhibited greater improvements in vertical jump height, standing long jump distance, and sprint performance compared to the control group, aligning with findings from previous research.

Supporting Studies

1. Huang et al. (2021) investigated the effects of plyometric training on lower limb power in elite martial arts athletes. Their study found that an 8-week plyometric training program led to an average increase of 10.8% in vertical jump performance. This aligns closely with the 12.4% increase observed in this study, reinforcing the effectiveness of explosive training protocols in enhancing athletic power.

2. Wang et al. (2020) conducted a study on Chinese martial artists and found that combining resistance training with explosive plyometrics significantly improves force production and jump execution efficiency. Their research demonstrated that athletes who followed a structured training plan integrating strength and plyometrics experienced better jump mechanics and faster sprint times. This supports the current study's findings that plyometric and resistance training contribute to enhanced movement performance in Wushu.

3. Liu & Zhang (2019) analyzed the relationship between strength training and combat sports performance and concluded that high-intensity resistance training improves neuromuscular efficiency and reduces the risk of injury in martial artists. The current study supports this claim, as athletes in the experimental group not only showed improved explosiveness but also reported fewer muscle fatigue issues, suggesting that structured training reduces injury risk while optimizing performance.

Discussion of Findings

1. The 12.4% increase in vertical jump height and 10.2% increase in standing long jump distance in the experimental group confirm that explosive training contributes directly to Wushu-specific movement demands.

2. The 8.7% reduction in sprint times demonstrates improvements in lower-body force generation, leading to quicker movements and better reaction times in Wushu techniques.

3. The 15.1% increase in Wushu performance scores suggests that athletes not only gained strength but also applied it effectively in their sport-specific movements.

These findings reinforce the importance of structured strength and plyometric training in developing martial arts-specific athletic performance.

Application in Wushu Training

The study confirms that integrating strength and plyometric exercises with Wushu-specific drills results in optimal athletic performance. Traditional Wushu training emphasizes technique, flexibility, and endurance, but lacks structured explosive training components. The results indicate that athletes benefit significantly from integrating strength training alongside their technical skill development.

Supporting Studies

1. Zhao et al. (2021) emphasized the importance of sport-specific strength training in martial arts. Their research found that athletes who included strength training in their routines performed better in power-based movements such as jump kicks and rapid footwork. This supports the current study's findings on improved Wushu performance scores, suggesting that power training enhances martial arts execution quality.

2. Chen & Wu (2020) examined the role of agility training in Wushu performance and discovered that athletes who engaged in speed and agility training alongside their standard practice routines demonstrated superior competition performance compared to those who only followed technical training. This aligns with this study's 50m sprint improvements, indicating that speed-focused drills enhance quickness and movement efficiency in combat sports.

3. Huang et al. (2019) found that sport-specific plyometric training improved lower limb biomechanics and reduced injury rates in martial artists. Their study suggested that explosive training methods reduce knee and ankle strain, preventing common overuse injuries. This is consistent with findings from the current study, where athletes in the experimental group reported fewer muscle fatigue issues, supporting the notion that structured explosive training contributes to injury prevention.

Practical Applications for Wushu Coaches and Trainers

1. Strength and Plyometric Training Must Be Integrated into Wushu Programs

- Coaches should incorporate explosive drills to improve jumping, sprinting, and rapid movement execution.
- Wushu athletes should not rely solely on technique training but should incorporate structured explosive exercises.

2. Sport-Specific Training Improves Skill Transfer

- Traditional resistance training must be tailored to match the biomechanical demands of Wushu.
- Plyometric exercises should replicate competition movements to enhance direct applicability.

3. Injury Prevention Through Explosive Training

- Progressive strength training can enhance joint stability, reducing the likelihood of injuries.
- Athletes who develop greater lower limb strength experience less knee and ankle strain, improving long-term performance sustainability.

The findings from this study confirm that plyometric and resistance training should be fundamental components of Wushu athletic development. By incorporating scientifically-backed explosive training programs, athletes can achieve higher power output, faster movement execution, and improved technical precision. These results align with existing research and provide strong evidence that structured training can enhance both performance and injury resilience in martial arts athletes.

Conclusion

1. Summary of Findings

This study aimed to develop and evaluate a structured training program to enhance lower limb explosive power in senior high school Wushu athletes. The findings confirmed that the 8-week structured training program, which integrated strength training, plyometrics, and sport-specific drills, significantly improved all key performance metrics.

2. Research Results Aligned with Study Objectives

The research set out to achieve three key objectives:

1. To develop a specific training program to enhance lower limb explosiveness in Wushu athletes.
 - Achieved: The structured plyometric and resistance training program was successfully developed, integrating exercises tailored to Wushu movements.
2. To compare explosive performance between athletes undergoing specific training and those following standard training.
 - Achieved: The experimental group significantly outperformed the control group in all performance metrics ($p < 0.05$).

3. To evaluate the effectiveness of the training program through quantitative performance tests.

o Achieved: The training program led to measurable improvements in jump height, sprint speed, long jump distance, and Wushu performance scores.

4. Key Performance Improvements

Table 3 Key Performance Improvements

Performance Metric	Experimental Group Improvement (%)	Control Group Improvement (%)
Vertical Jump Height	+12.4% ($p < 0.01$)	+2.7% (<i>not significant</i>)
Standing Long Jump Distance	+10.2% ($p < 0.05$)	+2.2% (<i>not significant</i>)
50m Sprint Time	-8.7% ($p < 0.05$)	-2.8% (<i>not significant</i>)
Wushu Performance Score	+15.1% ($p < 0.01$)	+2.8% (<i>not significant</i>)

5. Which Results Were Better?

- The experimental group outperformed the control group across all metrics.
- Wushu performance score (+15.1%) and vertical jump height (+12.4%) showed the most significant improvements.
- Sprint times improved (-8.7%), meaning faster acceleration and agility.

6. How Effective Was the Training?

- Highly effective: The specific training program produced 4-5 times greater improvements than standard training alone.
- Practical application: These findings confirm that plyometric and strength training are critical for enhancing Wushu performance.
- Significant athletic benefits: Athletes jumped higher, moved faster, and executed explosive techniques with greater power.

7. Implications for Wushu Training

7.1 Strength and Plyometric Training Should Be Core Components of Wushu Preparation

Traditional Wushu training emphasizes technique, but this study confirms that explosive strength is a key performance factor. Coaches should integrate:

- Jump training (for aerial movements and acrobatics).
- Plyometrics (for increasing kicking force and explosive strikes).
- Speed & agility drills (for quick footwork transitions).

7.2 Sport-Specific Strength Training Enhances Competitive Performance

This study validates the importance of tailored strength training:

- Explosive power translates into improved Wushu techniques.

- Strength gains lead to functional improvements in movement execution.
- Training adaptations help reduce injury risks.

7.3 Injury Prevention and Long-Term Athletic Development

Lower limb strength and stability reduce injury risks. This study supports prior findings that athletes who undergo structured explosive training experience fewer injuries (Huang et al., 2021). Coaches should:

- Implement progressive overload to avoid injuries.
- Incorporate flexibility and mobility drills for recovery.

8. Conclusion: Why This Study Matters

1. Proves that explosive training significantly enhances Wushu performance.
2. Demonstrates clear benefits in jumping, sprinting, and technical execution.
3. Supports integrating strength and plyometric exercises into Wushu coaching.
4. Provides a scientific basis for improving Wushu athlete performance.

Recommendation

Based on the findings of this study, the following recommendations are proposed to optimize Wushu training programs, improve athletic performance, and enhance injury prevention strategies for high school Wushu athletes.

1. Integration of Strength and Plyometric Training in Wushu Training Programs

This study demonstrates that combining strength and plyometric exercises significantly improves lower limb explosive power. Wushu coaches should:

Incorporate Progressive Plyometric Drills

- Box jumps, squat jumps, and depth jumps should be integrated at least 2–3 times per week to enhance jump height and explosive take-off movements.
- Progression should follow an increasing intensity model, ensuring continuous adaptation.

Implement Lower Limb Strength Training

- Exercises such as weighted squats, lunges, and deadlifts should be included twice per week to enhance muscle recruitment and neuromuscular efficiency.
- Strength training should complement technical Wushu training rather than replace it.

Use Sport-Specific Training Methods

- Strength and plyometric exercises should be adapted to mimic actual Wushu movements, ensuring direct performance transfer (e.g., jump kick drills with resistance bands)

2. Periodization of Training for Maximum Performance Gains

To optimize performance without overtraining, a structured periodization model should be used:

- Off-Season (Strength Phase)

- Focus on building maximum strength through resistance training and low-volume plyometrics.
 - Training should emphasize progressive overload with structured rest periods.
- Pre-Competition (Power & Explosiveness Phase)
 - Increase plyometric training volume while reducing heavy strength training.
 - Train explosive movements under fatigue conditions to replicate competition scenarios.
- 3. Competition Phase (Peak Performance & Maintenance)
 - Reduce total training volume to maintain strength and explosiveness while maximizing recovery.
 - Focus on high-quality execution of Wushu techniques under competition conditions.
- 4. Post-Season (Recovery & Injury Prevention)
 - Implement a lighter training schedule focusing on mobility, flexibility, and injury rehabilitation.

Injury Prevention Strategies for Wushu Athletes

Given the high-impact nature of Wushu, injury prevention should be prioritized:

1. Develop Joint Stability and Mobility
 - Include ankle and knee stability exercises to prevent landing-related injuries.
 - Strengthen hip and core muscles to improve balance and movement control.
2. Monitor Training Load and Recovery
 - Athletes should avoid excessive training volume without sufficient recovery periods.
 - Recovery techniques such as foam rolling, massage therapy, and active recovery exercises should be incorporated.
3. Encourage Proper Warm-Up and Cool-Down Routines
 - Pre-training warm-ups should include dynamic stretching and activation drills.
 - Post-training recovery should involve static stretching and muscle relaxation exercises.

Future Research Directions

While this study provides strong evidence for the effectiveness of explosive training, further research is needed in the following areas:

1. Gender Differences in Training Adaptations
 - Future studies should examine how explosive training impacts male vs. female Wushu athletes to develop gender-specific training recommendations.
2. Long-Term Effects of Explosive Training
 - A 6-month to 1-year study would provide insights into how training adaptations persist over time.
3. Biomechanical Analysis of Wushu Movements
 - Using motion capture technology and electromyography (EMG) would provide a deeper understanding of how lower limb muscles activate during explosive Wushu techniques.



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