

Effects of Optimal Power Load Training on Lower Limb Explosive Power and Sport-Specific Kicking Performance in Male Taekwondo Athletes

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Abstract: This study investigated the effects of Optimal Power Load Training (OPL) on lower limb explosive power and sport-specific kicking performance in male taekwondo athletes. Sixteen male athletes from the Taekwondo Team of Xi'an Physical Education University served as participants. The study employed literature review, experimental, testing, and statistical methods. Participants were randomly assigned to either an experimental group (n = 8) or a control group (n = 8). The experimental group underwent an individualized optimal power load training protocol based on each athlete's peak power output, while the control group followed a conventional resistance training protocol. The intervention lasted eight weeks. Outcome measures included standing long jump distance, squat jump (SJ) height and flight time, countermovement jump (CMJ) height and flight time, and 10-second consecutive bilateral roundhouse kick performance. The results demonstrated that both groups exhibited improvements in lower limb explosive power and sport-specific kicking performance following the eight-week intervention. However, the experimental group showed significantly greater gains in SJ performance, CMJ performance, consecutive kick frequency, and mean kick force, with several indicators reaching statistical significance ($P < 0.05$). These findings suggest that OPL training can effectively enhance lower limb explosive power and sport-specific technical output capacity in male taekwondo athletes, thereby exerting a positive influence on competitive performance. Accordingly, OPL training may serve as an important component of sport-specific strength conditioning in taekwondo. It should also be noted that factors such as athletes' age, competitive level, training background, and individual physical fitness may all influence training outcomes. Future studies should expand sample sizes and conduct more systematic investigations targeting diverse athlete populations.

Keywords: Taekwondo; Optimal Power Load; Lower Limb Explosive Power; Sport-specific Kicking Performance; Strength Training.

1. Introduction

Taekwondo is a competitive combat sport characterized primarily by rapid lower limb techniques, placing exceptionally high demands on athletes' speed, strength, agility, coordination, and neuromuscular control capacity. Lower limb explosive power not only determines the quality of technical execution but also directly influences striking speed, kick force magnitude, and the efficiency of offensive-defensive transitions during competition. Consequently, identifying scientifically grounded training methods to enhance lower limb explosive power in taekwondo athletes has become a prominent research priority in sport-specific physical conditioning.[1-3]

Previous research has demonstrated that elite taekwondo athletes must complete rapid ground reaction, hip rotation, and lower limb whipping actions within extremely brief time windows during competition, requiring the neuromuscular system to generate substantial force at high contractile velocities. Accordingly, explosive power level is considered a critical determinant of athletic performance and competitive outcomes. Tian Maijiu and colleagues posit that explosive power constitutes a fundamental component of competitive capacity, representing an integrated expression of both force and velocity. Wang Weixing et al. further argued that sport-specific strength training should emphasize the efficiency of neuromuscular force output under high-velocity movement conditions.[4]

Conventional strength training typically prioritizes the

development of maximal strength; however, for speed-strength sports such as taekwondo, improvements in absolute strength alone may not fully satisfy sport-specific requirements. In recent years, advances in sports biomechanics and sport science have directed increasing attention to the concept of the "optimal power load." This theoretical framework posits that within a specific load range, skeletal muscle can simultaneously maintain relatively high force output and movement velocity, thereby achieving maximal mechanical power output. Compared with traditional heavy-load strength training, OPL training is considered to be more congruent with the demands of speed-strength sports disciplines.[5]

From a sport physiology perspective, the force-velocity relationship in skeletal muscle reveals a clear trade-off between contractile velocity and force production at varying external loads. Excessively heavy loads result in a reduction of movement velocity, whereas excessively light loads fail to provide adequate force stimuli. Therefore, identifying the optimal power output zone and conducting targeted training within this load range may enhance neuromuscular recruitment efficiency and rapid force output capacity.

Current research on OPL training has been concentrated primarily in athletics, weightlifting, and basketball, with relatively limited experimental investigation into its specific effects on lower limb explosive power in taekwondo. In particular, systematic studies addressing sport-specific kicking capacity and the ability to sustain high-frequency movement output remain scarce. Therefore, the present study

recruited male taekwondo athletes as participants, implemented an OPL training intervention, and evaluated its effects on lower limb explosive power and sport-specific kicking performance, with the aim of providing both theoretical and practical reference for sport-specific strength conditioning in taekwondo.[6]

2. Research Participants and Methods

2.1. Research Participants

Sixteen male athletes from the Taekwondo Team of Xi'an Physical Education University were recruited as participants. All participants were aged 18–22 years, had prior resistance training experience, were in good health, and presented with no significant sports injuries or related medical conditions. All participants met the experimental testing requirements and provided voluntary informed consent prior to participation.

2.2. Research Methods

2.2.1. Literature Review

Drawing upon the library database resources of Xi'an Physical Education University and supplementary academic databases including CNKI (China National Knowledge Infrastructure) and VIP (Weipu), a systematic literature search was conducted using the following keywords: "optimal power load," "taekwondo," "lower limb explosive power," and "strength training." Relevant domestic and international research findings were systematically reviewed and synthesized to inform the experimental design and theoretical framework of the present study.

2.2.2. Experimental Method

(1) Group Assignment

Using a randomization procedure, the 16 participants were divided into an experimental group ($n = 8$) and a control group ($n = 8$). The experimental group underwent OPL training, while the control group followed a conventional resistance training protocol.

Table 1. Baseline Participant Characteristics

Basic Characteristics	Mean	p
Age (years)	20.13 ± 1.13	0.556
Height (cm)	186.14 ± 2.27	0.276
Body Mass (kg)	73.71 ± 4.79	0.956

(2) Experimental Design

The total intervention duration was eight weeks. The experimental group trained at loads corresponding to each individual's peak power output, as determined through pre-experimental testing, while the control group trained at fixed conventional loads. Both groups performed the hang power clean as the primary training movement, with identical training frequency, sets, repetitions, and rest intervals across groups. Throughout the intervention, all participants received standardized coaching supervision, and warm-up, training, and recovery procedures were strictly controlled to minimize the influence of extraneous variables on the experimental outcomes.

(3) Experimental Timeline

October 25–28, 2025: Familiarization with testing procedures and adaptation training
October 29–30, 2025: Pre-intervention testing
November 1 – December 18, 2025: Experimental intervention phase
December 19–20, 2025: Post-intervention testing

(4) Experimental Venue and Equipment

The experiment was conducted at the Taekwondo Training Hall of the Competitive Sports School of Xi'an Physical Education University. Equipment used included squat racks, barbells, a GymAware Power Measurement System, a JUST JUMP jump mat, electronic trunk protectors, and electronic foot sensors.

2.2.3. Testing Methods

Lower limb explosive power and sport-specific kicking performance were assessed using standing long jump, squat jump (SJ), countermovement jump (CMJ), and 10-second consecutive bilateral roundhouse kick tests.

(1) Optimal Power Load Assessment

The hang power clean was used as the testing movement.

Following completion of adaptation training, participants performed an incremental loading test using the GymAware Power Measurement System, commencing at 15 kg with 5 kg increments per stage. The load corresponding to maximal power output was identified via real-time power feedback data and designated as the individual's optimal power load.

(2) Standing Long Jump Test

Participants performed the standing long jump using standardized technique. Three trials were administered, and the best performance was recorded as the final result.

(3) SJ and CMJ Tests

Both tests were conducted using the JUST JUMP jump mat. The SJ required participants to maintain a half-squat static position prior to jumping; the CMJ required an immediate rebound jump following a rapid downward countermovement. Three trials were conducted for each test, and the best performance was retained.

(4) Sport-Specific Kicking Performance Test

A 10-second consecutive bilateral roundhouse kick test using electronic trunk protectors was administered. The number of consecutive kicks, effective hit rate, and mean kick force were recorded to assess sport-specific explosive power output.

2.2.4. Statistical Analysis

All experimental data were analyzed using SPSS version 26.0. Results are reported as mean ± standard deviation ($M \pm SD$). Within-group comparisons were conducted using paired-samples t-tests, with the level of statistical significance set at $P < 0.05$.

3. Results and Discussion

3.1. Standing Long Jump Performance

Table 2. Changes in Standing Long Jump Performance Before and After the Intervention (m)

Group	Pre-test	Post-test	t-value	p-value
Experimental	2.52 ± 0.12	2.54 ± 0.10	-3.325	0.005
Control	2.54 ± 0.09	2.56 ± 0.06	-4.465	0.012

Note: * $P < 0.05$, statistically significant; ** $P < 0.01$, highly statistically significant.

As presented in Table 2, following the eight-week intervention, both groups exhibited significant improvements in standing long jump performance. The experimental group improved from 2.52 ± 0.12 m at baseline to 2.54 ± 0.10 m post-intervention, while the control group improved from 2.54 ± 0.09 m to 2.56 ± 0.06 m. Paired-samples t-tests revealed statistically significant within-group improvements for both the experimental group ($P = 0.005 < 0.05$) and the

control group ($P = 0.012 < 0.05$). These results indicate that both training protocols effectively enhanced standing long jump performance, supporting the efficacy of the specialized training interventions employed in this study.

3.2. Squat Jump (SJ) and Countermovement Jump (CMJ) Performance

Table 3. Changes in Squat Jump (SJ) Performance Before and After the Intervention

	SJ Index	Pre-test	Post-test	t-value	p-value
Experimental	Flight Time (s)	0.65 ± 0.01	0.67 ± 0.20	-5.508	0.002
	Jump Height (cm)	52.24 ± 0.37	55.12 ± 0.77	-3.873	0.008
Control	Flight Time (s)	0.63 ± 0.03	0.65 ± 0.07	-3.464	0.013
	Jump Height (cm)	50.46 ± 4.00	53.28 ± 5.65	-3.009	0.024

Note: * $P < 0.05$, statistically significant; ** $P < 0.01$, highly statistically significant.

As shown in Table 3, following the eight-week intervention, SJ jump height and flight time increased in both groups. In the experimental group, jump height improved from 52.24 ± 0.37 cm to 55.12 ± 0.77 cm, and flight time from 0.65 ± 0.01 s to 0.67 ± 0.20 s. In the control group, jump height improved from 50.46 ± 4.00 cm to 53.28 ± 5.65 cm, and flight time from

0.63 ± 0.03 s to 0.65 ± 0.07 s. Paired-samples t-tests revealed that improvements in jump height ($P = 0.008 < 0.01$) and flight time ($P = 0.002 < 0.01$) reached a high level of statistical significance in the experimental group, while the control group demonstrated significant improvements in jump height ($P = 0.024 < 0.05$) and flight time ($P = 0.013 < 0.05$).

Table 4. Changes in Countermovement Jump (CMJ) Performance Before and After the Intervention

	CMJ Index	Pre-test	Post-test	t-value	p-value
Experimental	Flight Time (s)	0.64 ± 0.03	0.66 ± 0.02	-5.435	0.002
	Jump Height (cm)	58.75 ± 4.45	63.24 ± 2.61	-3.682	0.010
Control	Flight Time (s)	0.62 ± 0.02	0.63 ± 0.02	-2.750	0.033
	Jump Height (cm)	55.08 ± 4.11	57.68 ± 3.81	-3.045	0.023

Note: * $P < 0.05$, statistically significant; ** $P < 0.01$, highly statistically significant.

As shown in Table 4, CMJ jump height and flight time improved in both groups following the intervention. The experimental group progressed from 58.75 ± 4.45 cm and 0.64 ± 0.03 s pre-intervention to 63.24 ± 2.61 cm and 0.66 ± 0.02 s post-intervention; the control group advanced from 55.08 ± 4.11 cm and 0.62 ± 0.02 s to 57.68 ± 3.81 cm and 0.63 ± 0.02 s, respectively. Paired-samples t-tests indicated that the

experimental group achieved highly significant improvements in jump height ($P = 0.010 < 0.01$) and flight time ($P = 0.002 < 0.01$), while the control group showed significant improvements in jump height ($P = 0.023 < 0.05$) and flight time ($P = 0.033 < 0.05$).

3.3. Sport-Specific Kicking Performance

Table 5. Changes in Sport-Specific Kicking Performance Before and After the Intervention

	Sport-specific Index	Pre-test	Post-test	t-value	p-value
Experimental	Consecutive Kicks (n)	19.7 ± 1.8	21.2 ± 1.3	-9.354	0.024
	Mean Kick Force (bl)	40.0 ± 1.3	43.1 ± 2.9	-5.745	0.017
Control	Consecutive Kicks (n)	19.5 ± 0.9	20.1 ± 0.7	-2.646	0.053
	Mean Kick Force (bl)	38.2 ± 2.1	41.1 ± 1.4	-2.762	0.020

Note: * $P < 0.05$, statistically significant; ** $P < 0.01$, highly statistically significant.

As indicated in Table 5, the experimental group's consecutive kick count increased from 19.7 ± 1.8 to 21.2 ± 1.3 repetitions, and mean kick force increased from 40.0 ± 1.3 bl to 43.1 ± 2.9 bl. In the control group, kick count increased from 19.5 ± 0.9 to 20.1 ± 0.7 repetitions, and mean kick force from 38.2 ± 2.1 bl to 41.1 ± 1.4 bl. Statistical analysis revealed that both consecutive kick frequency and mean kick force reached statistical significance in the experimental group ($P < 0.05$), whereas only mean kick force attained significance in the control group, with consecutive kick frequency narrowly failing to meet the threshold ($P = 0.053$).

Sport-specific technical actions in taekwondo are characterized by rapid force output, requiring athletes to execute ground reaction, hip rotation, leg swing, and striking movements within extremely brief timeframes. As such, lower limb explosive power and sport-specific technical capacity are closely interrelated. OPL training, by simultaneously emphasizing movement velocity and force output, more closely approximates the biomechanical demands of taekwondo techniques than conventional resistance training. Furthermore, the emphasis on the integration of movement speed and force production in OPL training promotes neuromuscular coordination and movement execution efficiency, which may account for the more pronounced improvements in sport-specific kicking performance observed in the experimental group.

4. Conclusion and Recommendations

4.1. Conclusion

(1) OPL hang power clean training effectively improved lower limb explosive power in male taekwondo athletes, exerting positive effects on SJ, CMJ, and standing long jump performance.

(2) OPL training significantly enhanced sport-specific kicking performance, demonstrating distinct advantages in consecutive kick frequency and mean kick force relative to conventional training.

(3) Compared with traditional resistance training, OPL training more closely aligns with the speed-strength demands

of taekwondo and demonstrates superior efficacy in improving neuromuscular recruitment efficiency and rapid force output capacity.

4.2. Recommendations

(1) In taekwondo sport-specific physical conditioning programs, OPL training may be incorporated as a key method for developing lower limb explosive power, integrated with sport-specific technical movements in a comprehensive training framework.

(2) When designing training plans, coaches should account for individual differences among athletes, adjusting training loads rationally in accordance with each athlete's competitive level, physical fitness, and sport-specific needs.

(3) Future investigations should expand sample sizes and incorporate electromyography, motion capture, and sports biomechanics technologies to enable more in-depth examination of the mechanisms underlying OPL training adaptations.

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