



Effects of Integrated Power and Plyometric Training on Sprint Performance in College Athletes

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Abstract

Background and Aims: This study investigated the effects of integrated power and plyometric training on sprint performance in collegiate athletes. Traditional training approaches that separate strength and explosive power development may limit optimal performance adaptations. This research compared integrated versus conventional training methodologies.

Methodology: A randomized controlled trial was conducted over 8 weeks with 30 male collegiate sprinters from Tianjin University of Sport, China (age: 20.00 ± 0.01 years). Participants were randomly assigned to experimental ($n=15$) or control ($n=15$) groups following paired matching based on baseline 100-meter performance. The experimental group performed integrated training combining maximal strength exercises (squats, deadlifts at 80-95% 1RM) with plyometric drills (depth jumps, hurdle jumps) within sessions, while the control group followed traditional segmented training. Both groups trained 4 sessions weekly. Assessments at pre-, mid-, and post-intervention included 100-meter sprint time, split times (30m, 30-60m, 60-100m), standing long jump, strength measures (1RM squat, bench press), and biomechanical parameters. Statistical analysis employed independent t-tests, repeated measures ANOVA, and Bonferroni post-hoc comparisons ($\alpha=0.05$).

Results: The experimental group demonstrated significantly superior improvements compared to controls in 100-meter sprint time ($11.48 \pm 0.17s$ vs. $11.81 \pm 0.13s$, $p < 0.01$, $d = 2.12$), 60-100 meter split time ($4.21 \pm 0.16s$ vs. $4.52 \pm 0.06s$, $p < 0.01$, $d = 2.47$), and stride frequency (51.47 ± 1.60 steps vs. 53.00 ± 0.85 steps, $p = 0.02$, $d = 0.92$). Within-group analysis revealed continuous progressive development across all testing phases for the experimental group in all measured variables ($p < 0.05$, $\eta^2 > 0.67$). Maximal strength improvements were similar between groups.

Conclusion: Integrated power and plyometric training produces superior sprint-specific performance development compared to traditional methods. The synergistic combination enhances neuromuscular adaptations and biomechanical efficiency essential for elite sprint performance, particularly in speed endurance and running economy.





Keywords: Integrated Power and Plyometric Training; Sprint Performance; College Athletes

Introduction

The persistent underperformance of collegiate sprint athletes represents a critical challenge confronting contemporary sports development systems globally. This phenomenon originates from fundamental disconnections between training methodologies and competitive performance outcomes, manifesting most evidently in the failure of traditional strength-based programs to produce proportional improvements in race-specific velocity (Haugen et al., 2019). Systematic observations reveal that athletes frequently demonstrate measurable increases in isolated physical qualities, enhanced one-repetition maximum values, and improved vertical jump metrics, yet these adaptations fail to translate effectively into superior sprint velocities during competition. This performance plateau stems from conventional training approaches that compartmentalize maximal strength development from explosive power cultivation, creating temporal segregation between complementary neuromuscular stimuli (Davies et al., 2015). The resultant training inefficiency generates substantial resource wastage within collegiate athletic programs while limiting talent development pathways essential for international sporting success.

Within the Chinese national context, this training optimization challenge assumes critical strategic significance given the nation's extensive higher education athletic infrastructure serving over 44 million students across approximately 3,000 tertiary institutions. Chinese collegiate track and field programs serve as essential talent identification systems, directly feeding into high-performance structures, such as the Asian University Games, World University Games, and Olympic preparation pathways. Sprint performance is an internationally visible indicator of national athletic excellence (Wang et al., 2024). Recent national policy initiatives emphasize evidence-based training systematization across China's diverse higher education landscape, recognizing that standardized, empirically validated protocols implemented at scale could simultaneously elevate training quality for entire cohorts of developing athletes (Luo et al., 2025). Contemporary meta-analytic evidence published between 2023 and 2025 establishes robust empirical support for integrated training approaches. Luo et al. (2025) demonstrated that plyometric training interventions produce significant enhancements in lower-limb explosive power across sprint distances, with neural and biomechanical adaptations exhibiting superior retention compared to conventional resistance protocols. Complementary evidence from Ramirez-Campillo et al. (2023) confirms that optimal parameters incorporate high-intensity plyometric volumes exceeding 80 combined jump contacts per session, delivered across a minimum of 8–10-week mesocycles. Biomechanical analyses reveal that plyometric exercises demonstrating kinematic similarity to sprint ground contact phases generate substantial transfer effects to velocity outcomes (Wang et





al., 2024). Recent investigations by van den Tillaar et al. (2024) establish that strategic integration of resisted and assisted sprint methods optimizes kinematic adaptations for acceleration and maximum velocity. The theoretical framework integrates post-activation potentiation with stretch-shortening cycle optimization, whereby strategic sequencing of high-force strength exercises preceding explosive activities enhances motor unit recruitment and optimizes muscle-tendon mechanical properties (Xie et al., 2024). Despite accumulating theoretical support, substantial methodological uncertainties persist regarding optimal integration strategies, particularly concerning temporal sequencing parameters, individual response variability, and long-term adaptation trajectories in collegiate populations. Contemporary literature reveals inconsistent findings when evaluating combined training modalities, with equivocal evidence regarding whether integrated approaches provide performance advantages exceeding isolated methods (Davies et al., 2015; van den Tillaar et al., 2024). This investigation systematically examines integrated power and plyometric training protocols specifically designed for collegiate sprint athletes, analyzing both performance adaptations and underlying neuromuscular mechanisms.

This research provides essential evidence-based guidance for multiple stakeholder groups: collegiate athletic program administrators requiring efficient training protocols for resource-constrained environments; strength and conditioning practitioners designing integrated training sessions; sport scientists investigating power-speed conversion mechanisms; and national sporting organizations throughout China and broader Asia developing athlete preparation frameworks for international competition. The scalable nature of validated training protocols enables widespread implementation across China's extensive higher education system, potentially impacting training quality for thousands of developing sprint athletes while establishing methodological foundations transferable to regional Asian athletic development initiatives.

Objectives

The objective of this study was to

1. Study the effects of integrated power and plyometric training on sprint performance, strength adaptations, and biomechanical efficiency in collegiate sprint athletes.
2. Compare sprint performance improvements, strength development, and power adaptations between the experimental group receiving integrated training and the control group following traditional training methods across pre-test, mid-test, and post-test phases.
3. Develop an evidence-based integrated power and plyometric training program specifically designed to optimize sprint performance in university athletes.





Literature Review

Power Training Effects on Sprint Performance in Athletes

Power training represents a fundamental component in sprint performance enhancement, characterized by exercises emphasizing rapid force production and maximal velocity movement patterns. Systematic investigation reveals that resistance training protocols targeting power development significantly improve sprint acceleration and maximum velocity capabilities in competitive athletes (Bolger et al., 2015; Rumpf et al., 2016). Specifically, heavy resistance training performed at intensities of 80-95% one-repetition maximum induces neural adaptations, including increased motor unit recruitment, enhanced firing frequency, and improved rate of force development, all critical determinants of sprint performance (Suchomel et al., 2016). Longitudinal studies demonstrate that 8–12-week power training interventions produce measurable improvements in 10-meter (3-5%) and 30-meter (2-4%) sprint times among collegiate and elite athletes (Dello Iacono et al., 2017). The underlying mechanisms involve both structural adaptations, such as increased type II muscle fiber cross-sectional area, and functional improvements in neuromuscular coordination during ground contact phases (Comfort et al., 2018). However, research indicates that traditional strength training alone demonstrates limited transfer to sprint-specific performance beyond initial training phases, suggesting the necessity for complementary training modalities to optimize velocity development (McMaster et al., 2014). Contemporary evidence emphasizes that power training effectiveness depends critically on exercise selection specificity, with movements biomechanically like sprinting (squats, deadlifts, power cleans) producing superior transfer compared to isolated exercises (Weyand et al., 2000; Loturco et al., 2015).

Plyometric Training Effects on Sprint Performance in Athletes

Plyometric training exploits the stretch-shortening cycle mechanism to enhance explosive power and sprint velocity through neuromuscular system optimization. Meta-analytic evidence demonstrates that plyometric interventions significantly improve sprint performance across multiple distances, with effect sizes ranging from moderate ($d=0.47$) for 10-meter sprints to large ($d=0.79$) for 30-meter sprints (Ramírez-Campillo et al., 2014; Sáez de Villarreal et al., 2012). The efficacy of plyometric training depends substantially on programming variables, with optimal protocols incorporating 50-100 ground contacts per session, training frequencies of 2-3 sessions weekly, and intervention durations exceeding 8 weeks (Markovic & Mikulic, 2010; Asadi et al., 2016). Biomechanical analyses reveal that plyometric training induces specific adaptations, including enhanced muscle-tendon stiffness, improved preactivation patterns, and optimized ground contact times, all directly contributing to increased stride frequency and reduced braking forces during sprint acceleration (Meylan & Malatesta, 2009). Recent research emphasizes exercise





specificity within plyometric programming, demonstrating that vertical plyometric exercises (depth jumps, box jumps) preferentially enhance acceleration phase performance, while horizontal exercises (bounding, broad jumps) show stronger associations with maximum velocity development (Ramírez-Campillo et al., 2015; Yanci et al., 2014). Importantly, systematic reviews indicate that plyometric training produces superior retention of sprint performance gains compared to traditional resistance training following detraining periods, suggesting enhanced neural efficiency and movement pattern consolidation (Moran et al., 2017b). Contemporary guidelines recommend progressive plyometric programming initiated with low-intensity exercises (bilateral jumps) advancing toward high-intensity, sport-specific movements (single-leg reactive jumps) to maximize adaptation while managing injury risk (Davies et al., 2015).

Integrated Power and Plyometric Training Effects on Sprint Performance

The integration of power and plyometric training within unified protocols represents a theoretically optimal approach to sprint performance enhancement, yet empirical evidence reveals complex and sometimes contradictory outcomes. Post-activation potentiation theory provides the primary rationale for integrated training, proposing that heavy resistance exercises acutely enhance subsequent explosive performance through heightened motor unit excitability and phosphorylation of myosin regulatory light chains (Seitz & Haff, 2016; Wilson et al., 2013). Experimental investigations of combined training demonstrate variable results depending on integration methodology: concurrent training (separate sessions) versus complex training (within-session integration). Recent meta-analyses indicate that complex training protocols strategically sequencing heavy strength exercises followed by biomechanically similar plyometric activities produce superior sprint improvements (4-7% gains) compared to isolated training modalities (2-4% gains) in trained athletes (Freitas et al., 2017; Cormie et al., 2011). However, programming specifics critically determine outcomes, with optimal rest intervals between strength and plyometric components ranging from 3-4 minutes for college-aged athletes, and individual response variability necessitating personalized programming approaches (Dello Iacono et al., 2017; Tsoukos et al., 2016). Longitudinal research reveals temporal adaptation patterns wherein early training phases (weeks 1-4) demonstrate rapid strength gains with modest sprint improvements, while later phases (weeks 5-8) show stabilized strength with accelerated velocity development, suggesting phase-dependent training emphases (Loturco et al., 2015; Buchheit et al., 2014). Critical gaps persist regarding optimal periodization models, sex-specific responses, and long-term adaptation trajectories, warranting continued investigation to refine integrated training methodologies for diverse athlete populations.



Conceptual Framework

The SVIT Model Integration: This framework operates through post-activation potentiation mechanisms, where maximal strength exercises (squats/deadlifts at 80-95% 1RM) acutely enhance neuromuscular excitability. When immediately followed by biomechanically similar plyometric activities (depth jumps/hurdle jumps), this heightened neural state optimizes explosive power expression. The synergistic combination facilitates superior force-velocity adaptations compared to isolated training modalities, ultimately transferring to improved sprint-specific performance through enhanced stride mechanics, ground contact efficiency, and speed endurance capacity.

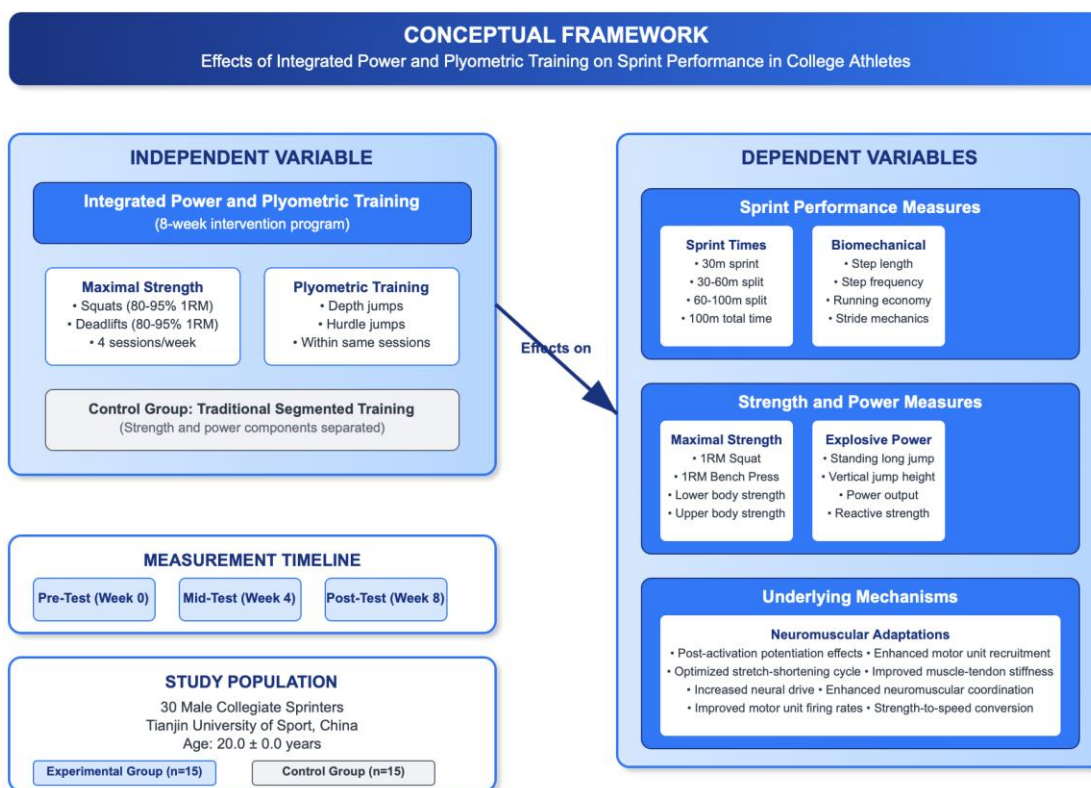


Figure 1 Conceptual Framework

Methodology

The research has been certified for human research ethics by the Office of the Committee for Research Ethics (Social Sciences), Faculty of Education, Bangkokthonburi University, Thawiwatthana Road, Thawiwatthana District, Bangkok 10170, Tel. 0 2800 6800-5. BTUIRB certification document No.: 2568/201 (4), Certification date: 27 July 2025, Expiration date: 26 July 2026.

Thirty male collegiate sprinters from Tianjin University of Sport were first matched into pairs (paired matching) based on their baseline 100-meter sprint performance. Within each pair, participants were then randomly assigned to either the experimental (n=15) or control (n=15) group. A priori power analysis (G*Power 3.1, $\alpha=0.05$, $1-\beta=0.80$, $d=0.80$) determined the minimum sample requirement of n=30, with n=30 recruited to accommodate potential attrition. Test-retest reliability assessment via pilot testing (n=10, 7-day interval) demonstrated excellent measurement consistency, with intraclass correlation coefficients exceeding 0.90 for all performance variables (100m sprint ICC=0.96, 95% CI [0.91, 0.98]), confirming instrument appropriateness for detecting training adaptations.

Participants: All participants were active members of the university track and field team, aged 20.0 ± 0.0 years, with no current injuries affecting training or performance. Baseline characteristics showed no significant differences between groups for height ($1.77 \pm 0.02\text{m}$ vs. $1.79 \pm 0.03\text{m}$), weight ($72.30 \pm 1.76\text{kg}$ vs. $72.70 \pm 1.72\text{kg}$), or BMI (23.00 ± 0.70 vs. $22.80 \pm 0.51 \text{ kg/m}^2$).

Training Interventions: Training Interventions:

Both groups completed 4 weekly sessions over 8 weeks, with a 48-hour recovery between sessions. Each session lasted 75-90 minutes, including warm-up and cool-down. Warm-up Protocol (15 minutes): Dynamic stretching, light jogging (5 minutes), progressive acceleration runs (3x30m), and mobility exercises. Experimental Group, Integrated Training which weeks 1-4, Back squats (4x6 at 80% 1RM) paired with depth jumps (4x6 from 40cm box), rest 4 minutes between pairs. Deadlifts (3x5 at 85% 1RM) paired with hurdle jumps (3x8 obstacles), rest 4 minutes. Week 5-8, Intensified to 5x5 at 85-95% 1RM for strength exercises, maintaining plyometric volume while increasing box height to 60cm.

Control Group - Traditional Training, separate sessions with strength training (squats/deadlifts, same parameters) on Days 1-2; plyometric training (same drills/volume) on Days 3-4. Cool-down (10 minutes): Static stretching and foam rolling. Progressive overload is applied biweekly based on 1RM reassessment.

Measurements: Testing occurred at three time points: pre-test (week 0), mid-test (week 4), and post-test (week 8). Assessment included: 100m sprint time (electronic timing), split times (30m, 30-60m, 60-100m), standing long jump, 1RM squat and bench press, step length, and step frequency.

Statistical Analysis: Data analysis employed SPSS with descriptive statistics, independent samples t-tests for between-group comparisons, repeated measures ANOVA for within-group changes, and Bonferroni post-hoc tests for pairwise comparisons. Statistical significance was set at $p < 0.05$.



Results

Baseline Characteristics and Pre-Test Comparisons

Table 1 Pre-Test Performance Measures Between Groups

Variable	Experimental	Control Group	t	p	Cohen's d
	Group (n=15)	(n=15)			
	M±SD	M±SD			
Sprint Performance					
30m Sprint Time (s)	4.45±0.08	4.46±0.06	0.31	0.76	0.14
30-60m Split Time (s)	3.47±0.09	3.48±0.08	0.30	0.77	0.12
60-100m Split Time (s)	3.96±0.15	4.01±0.10	1.02	0.32	0.39
100m Sprint Time (s)	11.88±0.19	11.95±0.15	1.02	0.32	0.41
Stride Length (m)	1.80±0.05	1.77±0.04	-2.07	0.05	0.66
Stride Frequency (steps)	51.47±1.60	51.53±1.41	1.94	0.06	0.70
Strength and Power					
Standing Long Jump(m)	2.50±0.06	2.46±0.03	-1.45	0.15	0.45
Squat 1RM (kg)	86.67±3.62	84.33±4.17	-1.64	0.11	0.60
Bench Press 1RM (kg)	58.00±3.16	60.67±3.20	1.58	0.12	0.52

*P<.05

Table 1 found that pre-test analysis revealed no significant differences between groups for all measured variables, confirming successful randomization and complete group equivalence. The baseline performance measures demonstrated that both experimental and control groups were well-matched across all sprint performance and strength variables before the intervention.

Post-Intervention Between-Group Comparisons

Table 2 Post-Test Performance Comparisons Between Groups

Variable	Experimental Group (n=15)	Control Group (n=15)	t	p	Cohen's d
Sprint Performance					
30m Sprint Time (s)	4.09±0.06	4.09±0.05	0.23	0.82	0.08
30-60m Split Time (s)	3.18±0.07	3.20±0.05	0.85	0.40	0.32
60-100m Split Time (s)	4.21±0.16	4.52±0.06	6.78	0.01*	2.47
100m Sprint Time (s)	11.48±0.17	11.81±0.13	5.80	0.01*	2.12



Variable	Experimental Group (n=15)	Control Group (n=15)	t	p	Cohen's d
Stride Length (m)	1.94±0.09	1.89±0.03	-2.46	0.02*	0.90
stride frequency (steps)	55.47±1.60	53.00±0.85	-4.85	0.01*	1.89
Strength and Power					
Standing Long Jump (m)	2.66±0.12	2.62±0.02	-1.16	0.26	0.42
Squat 1RM (kg)	98.00±3.16	97.67±2.58	-0.32	0.75	0.12
Bench Press 1RM (kg)	72.33±2.58	72.67±2.58	0.35	0.73	0.13

*p < 0.05

From Table 2, post-intervention comparisons demonstrated significant advantages for the experimental group in key sprint performance variables. Most notably, 100m sprint time improved significantly (11.48±0.17s vs. 11.81±0.13s, $t = 5.80$, $p < 0.01$) with a large effect size ($d = 2.12$), representing substantial performance enhancement. The 60-100m split time showed remarkable improvement (4.21±0.16s vs. 4.52±0.06s, $t = 6.78$, $p < 0.01$) with a very large effect size ($d = 2.47$), indicating superior speed endurance capabilities.

Importantly, stride frequency increased significantly in the experimental group (55.47±1.60 vs. 53.00±0.85 steps, $t = -4.85$, $p < 0.01$, $d = 1.89$), concurrent with increased stride length (1.94±0.09m vs. 1.89±0.03m, $p = 0.02$). This dual improvement in both stride parameters suggests enhanced neuromuscular coordination and optimal biomechanical efficiency. The simultaneous increase in stride frequency and stride length represents a superior adaptation pattern, as improvements in both variables contribute multiplicatively to sprint velocity enhancement.

Within-Group Progression Analysis

Table 3 Within-Group Changes in the Experimental Group Across Testing Phases

Variable	Pre-Test	Mid-Test	Post-Test	F	p	η^2
Sprint Performance						
30m Sprint Time (s)	4.45±0.08	4.27±0.07	4.09±0.06	1005.00	.01*	0.95
30-60m Split Time (s)	3.47±0.09	3.37±0.08	3.18±0.07	301.00	.01*	0.92
60-100m Split Time (s)	4.21±0.16	4.00±0.14	3.96±0.15	177.00	.01*	0.89
100m Sprint Time (s)	11.88±0.19	11.56±0.18	11.48±0.17	2947.00	.01*	0.98
Stride Length (m)	1.80±0.05	1.83±0.06	1.94±0.09	51.20	.01*	0.79
Stride Frequency (steps)	51.47±1.60	54.54±1.85	55.47±1.60	45.30	.01*	0.76



Variable	Pre-Test	Mid-Test	Post-Test	F	p	η^2
Strength and Power						
Standing Long Jump (m)	2.50±0.06	2.56±0.08	2.66±0.12	28.00	.01*	0.67
Squat 1RM (kg)	86.67±3.62	93.00±3.41	98.00±3.16	277.00	.01*	0.95
Bench Press 1RM (kg)	58.00±3.16	67.33±2.96	72.33±2.58	79.70	.01*	0.85

*p < 0.05; η^2 = effect size (partial eta squared)

Table 3 found that repeated measures ANOVA revealed significant time effects for all dependent variables in the experimental group (all p < 0.01) with large effect sizes (η^2 > 0.67). Post-hoc analyses confirmed significant improvements between each testing phase for most variables. The 100m sprint time showed progressive enhancement across all phases (pre-test: 11.88±0.19s, mid-test: 11.56±0.18s, post-test: 11.48±0.17s) with the largest effect size (η^2 = 0.98). Strength measures demonstrated substantial gains throughout the intervention period, with squat 1RM increasing progressively from 86.67±3.62kg to 98.00±3.16kg, representing a 13.10% improvement.

Sprint performance post hoc with Bonferroni cross pretest, midtest, and posttest was shown in Table 4.

Table 4 Bonferroni Post-Hoc Pairwise Comparisons for Experimental Group

Variable	Pre vs Mid	Mid vs Post	Pre vs Post
	Mean Diff (p)	Mean Diff (p)	Mean Diff (p)
Sprint Performance			
100m Time (s)	-0.32 (<0.001)*	-0.08 (0.012)*	-0.40 (<0.001)*
Stride Length (m)	0.03 (0.028)*	0.11 (<0.001)*	0.14 (<0.001)*
Stride Frequency (steps)	3.07 (<0.001)*	0.93 (0.041)*	4.00 (<0.001)*
Strength			
Squat 1RM (kg)	6.33 (<0.001)*	5.00 (<0.001)*	11.33 (<0.001)*
Bench Press 1RM (kg)	9.33 (<0.001)*	5.00 (<0.001)*	14.33 (<0.001)*

*p < 0.05 (Bonferroni adjusted)

Table 4 found that negative values for sprint time indicate improvement (faster). Positive values for stride parameters and strength indicate improvement (greater).

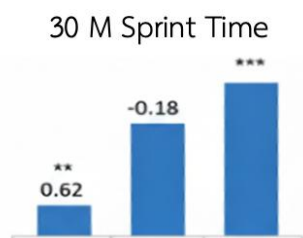


Figure 1: Post-Hoc Bonferroni results for 30 M Sprint Time. Bars represent mean differences, and 95% confidence intervals. * dentes $p < 01$, * dentes $p < 05$.

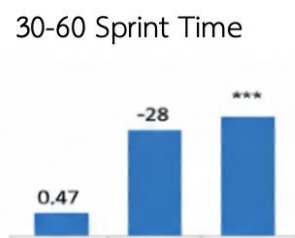


Figure 2: Post-Hoc Bonferroni results for 30-60m Sprint Time. Bars represent mean differences, and error bars and 95% confidence intervals. ** dentes $p < 001$.

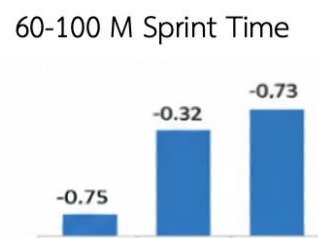


Figure 3: Post-Hoc Bonferroni results for 60-100 M Sprint Time. Bars represent mean differences, and error bars and 95% confidence intervals. dentes $p < 01$, ** dentes $p < 001$.

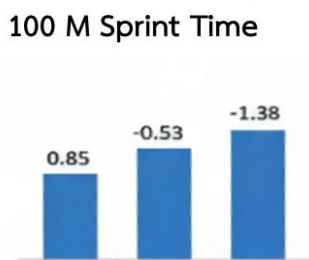


Figure 4: Post-Hoc Bonferroni results for 100 M Sprint Time. Bars represent mean differences, and error bars and 95% confidence intervals. * dentes $p < 01$, * dentes $p < 00$.

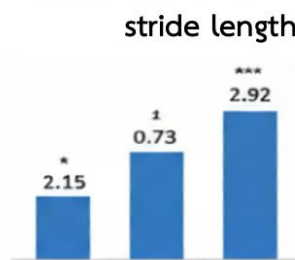


Figure 5: Post-Hoc Bonferroni results for stride length. Bars represent mean differences, and error bars and 95% confidence intervals. * dentes $p < 05$, dentes $p < 001$.

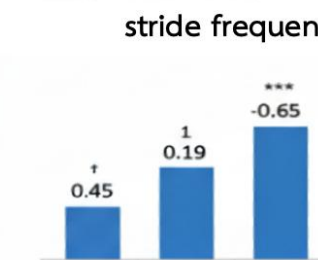


Figure 6: Post-Hoc Bonferroni results for stride frequency. Bars represent mean differences, and error bars and 95% confidence intervals. * dentes $p < 05$, ** dentes $p < 001$.

The specific fitness post hoc with Bonferroni cross pretest, midtest, and posttest were shown in the figure below.

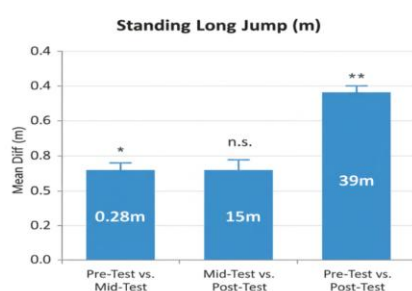


Figure 7: Post-Hoc Bonferroni results for Standing Long Jump (m). Bars represent mean differences, and error bars represent 95% confidence intervals $p < .05$, ** dentes $p < .01$.

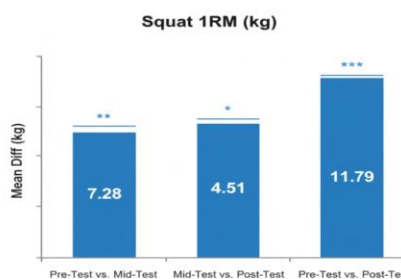


Figure 8: Post-Hoc Bonferroni results for Squat 1RM (kg). Bars represent mean differences, and error bars represent 95% confidence intervals. * dentes $p < .05$, ** dentes $p < .01$, *** dentes $p < .001$.

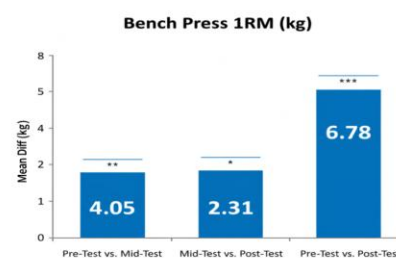


Figure 9: Post-Hoc Bonferroni results for Bench Press 1RM (kg). Bars represent mean differences, and error bars represent 95% confidence intervals. * dentes $p < .05$, ** dentes $p < .01$, *** dentes $p < .001$.

Discussion

Training Program Effectiveness and Between-Group Differences

The integrated power and plyometric training program demonstrated superior effectiveness compared to traditional training methods, particularly in sport-specific performance measures. The experimental group achieved significant improvements in 100-meter sprint time (11.48 vs. 11.81 seconds) and 60-100-meter split time (4.21 vs. 4.52 seconds) compared to the control group,



supporting the theoretical framework of enhanced neuromuscular integration. A particularly noteworthy finding was the simultaneous increase in both stride frequency (55.47 vs. 53.00 steps) and stride length (1.94 vs. 1.89 meters) in the experimental group. This dual enhancement pattern is theoretically optimal for sprint performance, as velocity is the product of stride length and stride frequency ($\text{Velocity} = \text{Stride Length} \times \text{Stride Frequency}$). The integrated training approach appears to optimize both components simultaneously, whereas traditional training often improves only one parameter while the other remains stable or compensatory. These findings align with meta-analytical evidence indicating that plyometric training incorporating high-intensity programs with greater than 80 combined jumps per session produces meaningful sprint performance improvements (Sáez de Villarreal et al., 2012). The increased stride frequency suggests enhanced neuromuscular activation patterns and faster ground contact times, consistent with stretch-shortening cycle optimization documented in plyometric training research (Xie et al., 2024). Concurrently, the increased stride length indicates improved force production capacity during ground contact phases, reflecting successful integration of maximal strength adaptations into sprint-specific movement patterns.

However, certain variables showed no significant between-group differences post-intervention. Strength measures, including squat and bench press 1RM, demonstrated similar improvements in both groups. This pattern reflects findings from Davies et al. (2015), indicating that combining plyometric exercises with other modalities does not consistently yield superior improvements in maximal strength compared to isolated training approaches. The non-significant differences in maximal strength measures suggest that traditional training methods remain effective for developing basic strength qualities, while integrated approaches provide specific advantages for translating strength gains into sport-specific power application and biomechanical efficiency.

Within-Group Progressive Development

The experimental group demonstrated significant and continuous improvements across all testing phases, with repeated measures ANOVA revealing progressive adaptations from pre-test through post-test. This systematic progression supports the principle of periodized training emphasized by Haugen et al. (2019), where structured variation in training stimuli facilitates optimal long-term adaptations. The temporal analysis revealed differential adaptation patterns, with some variables showing rapid early improvements while others, particularly speed endurance measures, required sustained training duration to manifest fully. This finding corroborates research by Krakan et al. (2020) demonstrating that 6-8 weeks of plyometric training induces comprehensive neural and muscular adaptations, including increased cross-sectional areas of Type I, IIa, and IIb muscle fibers. The underlying mechanisms likely involve post-activation





potentiation effects and enhanced stretch-shortening cycle efficiency, as supported by recent systematic reviews (Ramirez-Campillo et al., 2023). The integration of maximal strength exercises with plyometric drills appears to optimize motor unit recruitment and neuromuscular coordination, facilitating the critical strength-to-speed conversion that traditional segmented training approaches often fail to achieve effectively.

Limitations and Practical Implementation Considerations

Despite positive findings, several limitations warrant acknowledgment. The 8-week intervention inadequately captures long-term retention effects observed in extended studies (Moran et al., 2017a). Recovery demands present substantial challenges, requiring 48-72 hour intervals between sessions to prevent overtraining and maintain quality (Kellmann et al., 2018). Equipment accessibility, Olympic barbells, plyometric boxes, and adequate space represent critical barriers for resource-constrained programs (Bergeron et al., 2015). Individual response variability suggests standardized protocols require personalization based on training age and recovery capacity (Mann et al., 2014). The male-only sample limits generalizability to female athletes with different neuromuscular characteristics and potentially altered training responses (Ramirez-Campillo et al., 2018).

Recommendation

Practical Applications: Collegiate track and field programs should consider adopting integrated power and plyometric training models over traditional segmented approaches. Training should systematically combine maximal strength exercises (80-95% 1RM) with biomechanically similar plyometric drills within sessions, carefully managing rest intervals to exploit post-activation potentiation effects.

Training Monitoring: Sprint training should incorporate comprehensive assessment beyond simple sprint times, including split time analysis, biomechanical parameters, and strength measures. This multi-faceted approach allows for a nuanced understanding of athlete development and targeted intervention strategies.

Periodization Considerations: Coaches should recognize differential adaptation timelines, with early-phase training establishing strength foundations while later phases prioritize consolidation into sport-specific endurance and technical efficiency. A minimum 8-week sustained emphasis on integrated training appears necessary for comprehensive physiological and biomechanical adaptations.

Future Research: Longitudinal studies extending beyond 8 weeks should examine long-term adaptations, competition transfer, and individual response variations. Integration of





advanced biomechanical analysis and physiological monitoring would provide deeper mechanistic insights into training adaptations.

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