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Effects of Resistance Training Periodization on Power Output and Sprint Performance in Track Athletes

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ABSTRACT

The purpose of this study was to determine the effect of resistance training periodization on power output and sprint performance in a cohort of track athletes. The researchers employed an experimental design—repeated measures. There were twenty male (100 m, 200 m, and 400 m) track athletes that took part in the study. The participants completed an 8-week periodized program utilising resistance training consisting of three sessions per week progressing from maximal strength development to strength–power conversion. Performance variables included countermovement jump (CMJ), peak power, 10 m and 30 m sprint time, and force–velocity profile indicators (F_0 , V_0 , and P_{max}). Pre- and post-tests were conducted under controlled conditions. For statistical analyses, paired-samples t -tests were performed, and significance was set at $p \leq 0.05$; effect sizes (Cohen's d) were also calculated. Consequently, the authors found that all variables improved, with CMJ height and CMJ peak power increasing 11.76% and 10.29%, respectively, highlighting an improvement in lower-limb explosive power. Sprint performance was significantly improved (4.40% and 3.74% reductions in 10 m and 30 m sprint times, respectively). There were positive adaptations according to the force–velocity profile variables, with F_0 (+7.48%), V_0 (+3.91%), and P_{max} (+9.75%) values all increasing. The authors reported that the effect sizes were mostly large. In conclusion, our findings indicated that periodized resistance training increased both power output and 10m sprint times in track athletes. Progressively transitioning from maximal strength to explosive power appears to be an effective approach to enhance neuromuscular adaptations and sprint-specific performance in this population. As such, periodized resistance training should be integrated within sprint training programs to optimize athletic performance.

Keywords: Resistance training; Periodization; Sprint performance; Power output; Force–velocity profile; Track and field

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Kata Kunci: Resistance training; Periodization; Sprint performance; Power output; Force–velocity profile; Track and field

INTRODUCTION

The most familiar types of athlete to the general public, track and field sprinters also occupy some of the highest points in the sports human hierarchy of performance. Sprinting events in track and field are purely athletic events: there is no manipulation of ball, club, or cushion, no assistance from wind or water and wear. Track and field sprints are banquets where the celebrants are high on all the bodily systems and eating 'wholesome dirt', as Arthur Lydiard described the training of the great Australian sprinter, Peter Snell. The 'exceedingly ravenous appetite', as another distinguished exponent of this meal (the naïve in health terms are the scoffers at) my brother Mr Dylan), feeds on potentially perfect delivery of clean burning oxygen to every pack of muscle fibreations in the host odyssey (such things happen only in the Olympics). "The sprints represent one of the most demanding physiologically and biomechanically of all events in sport": the athlete's capacity to produce high power output in short time as well as properties of neuromuscular coordination (Haugen et al., 2019).

Resistance training has long been associated with the development of sprint performance owing to its role in contributing to increased maximal strength, RFD, and explosive power, according to both neural (motor unit recruitment and firing frequency) and muscular (hypertrophic) adaptations (Bolger et al., 2015). More recent literature emphasizes the need to consider sprint-specific parameters such as movement velocity, patterns of force application consideration as well as raw biomechanical considerations (Van Hooren & Bosch, 2024).

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However, no matter the type of resistance training performed, the effectiveness will also be reliant on the manner in which training variables (intensity, volume, frequency) are sequenced over a training timeline. This practice, known as periodization, refers to the planned and systematic sequencing of training variables to optimize the training outcome, and at the same time limiting fatigue and risk of overtraining (Lorenz et al., 2015). Periodization models generally contain some type of gradual shift from general strength work into more specific and explosive phases of training in order to align physiological adaptations with competition needs.

In sprint trained athletes, periodized resistance training aids the transfer from general strength to that required for the specific powers needed for the sport. More contemporary models will include phases of training, such as a general preparation, specific preparation and competition, with each eliciting different training responses and emphasis. Concurrently with training, resistance training may be combined with plyometric and sprint specific activities to promote transfer of strength (Hicks et al., 2022; Sanz-Matesanz et al., 2025).

There is empirical support concerning the efficacy of periodised resistance training to improve such 'sprint-related' variables. For example, Moir et al. (2007) showed that 8 weeks of periodised resistance training leads to improved maximal strength and explosive power, which in turn leads to improved short-distance sprint performance. Indeed, systematic reviews have established the positive efficacy of actually resistance-based training interventions to meaningfully improve sprint times when properly designed with progression and specificity strategies (Bolger et al., 2015).

Nevertheless, it is worth noting that the link between weight training and sprinting performance is complex and multifactorial: if excessive increases in muscle mass were to occur, these may impair performance due to increased somatic mass and reduced "economy of movement" (Van Hooren & Bosch, 2024).

Modern concepts in sports science emphasize the relevance of tracking training load, along with recognizing the balancing act of fatigue and recovery as a means of shaping adaptations to performance. Current examples of periodization are beginning to reflect nonlinear and individualized models with the awareness that an athlete's response to training can never be fully linear, indicating interactions between the physiological stressors and recovery processes (Kontro et al., 2025). And that biomechanical determinates such as the force-velocity relationship may give information about the efficacy of training interventions and transfer to sprint performance (Hicks et al., 2022).

While there are several studies in this area, especially since the beginning of the 21st century, there is still a relative dearth of research around the modulation of periodization schemes around physical power output and sprinting performance within track and field. Involved studies tend to either involve singular training interruptions, or fail to measure a sufficiently thorough combination of physiological and performance variables, leading to confounding results between cohort and accumulation of training history (Bolger et al., 2015).

Given these considerations, the aim of the current study was to examine the effects of resistance training periodization on power output and sprint performance in track athletes. Through exploring the interaction between programming and performance adaptation, it was hoped that useful insights could be uncovered to aid

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training design and ultimately make a genuine contribution to the goal of improving performance in our athletes.

METHODS

Study Design

This study used a repeated measures experimental design to investigate the effects of resistance training periodization on power output (in weightlifting as a proxy strength lift) and sprint performance in individual track athletes. Subjects were assessed before and after (of an 8-week periodized resistance training program). This design was appropriate to use as sprint performance is sensitive to structured interventions pertaining to neuromuscular and to a lesser degree strength manifestation (where training loads are systematically manipulated across time).

Participants

The 20 male track athletes chosen for this study, specializing in sprinting events such as the 100 m, 200 m and 400 m, were intentionally chosen from university affiliated athletics teams and the club setting only. The average values recorded for these athletes included age (21.40 ± 1.67 years), body mass (71.85 ± 5.94 kg), height (1.78 ± 0.06 m) and training age (4.30 ± 1.21 years). All of the athletes who participated had completed regular sprint training, were medically fit, had no musculoskeletal injury in the previous 3 (three) months and had experience with resistance training.

Criteria for inclusion: Competing regularly in training; performing systematic training for a minimum of 3 years; being free from any cardiovascular, orthopedic, or neurological impairments that would impair performance testing. Excluded from final analysis: subject had less than 90% of scheduled training sessions; individual sustained injury during the intervention period.

The researchers provided an explanation of the purpose and methods of their research to all athletes prior to collecting any data, and they received written consent from each participant. All procedures used in collecting data followed ethical guidelines established for studies involving human beings.

Table 1. Sample Description

Variable	Unit	Mean \pm SD
Age	years	21.40 ± 1.67
Height	m	1.78 ± 0.06
Body mass	kg	71.85 ± 5.94
Training age	years	4.30 ± 1.21
Sample size	n	20

Research Setting

This investigation took place at both the athletics track of the College of Physical Education and Sports Sciences, as well as the strength-training lab within the college. Both the baseline measurement and post-intervention measurements were conducted under identical environmental conditions and approximately at the same time during the day in order to reduce any possible circadian effects or influence from other environmental conditions. All subject participants were directed not to perform any

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vigorous exercise for 24 hours prior to their baseline and post-intervention testing and to follow normal dietary habits and sleep patterns throughout the entire study duration.

Anthropometric Measurements

Body height was measured using a stadiometer to the nearest 0.1 cm. Body mass was measured using a digital scale that had been previously calibrated and could measure body mass to within 0.1 kg. These measurements were obtained prior to performance testing to provide descriptive statistics for the sample as well as to assist in the interpretation of performance change over time.

Performance Variables

The study focused on two main dependent variables:

1. Power output
2. Sprint performance

Lower limb explosive performance assessments were used to determine total power output. Short sprint tests, which reflect both the acceleration and maximum-speed potential of a sprinter, were used to assess sprint performance. Jump and sprint-based measures of performance are used broadly in athlete monitoring, because they have good field practicality and sensitivity to neuromuscular performance changes.

Tests and Measurements

1. Countermovement Jump Test (CMJ)

The countermovement jump test was used to evaluate lower body power output. Each subject performed 3 maximal attempts with hands placed on hips to eliminate any influence from arm swings. One minute of rest was allowed between attempts and only the highest score was averaged for analysis. Jump heights were recorded in centimeters and peak power was estimated via the values associated with the highest attempt. The CMJ was selected, as it is a well-known reliable test for assessing explosive lower extremities performance and neuromuscular readiness.

2. 30-m Sprint Test

Maximal sprint performance was evaluated for the 30 m (initially standing) sprint test from a stop for time taken in 30 m and time on 10 m. Each trial had timing gates positioned at 0, 10, and 30 m to determine time for acceleration, and total time. The three maximal efforts were performed on 3- to 5-minute intervals with adequate rest between each trial with the best trial used for statistical purposes. Evaluating acceleration and sprint mechanics using split times due to 10 m and 30 m is well known and widely used by researchers to monitor performance improvements in trained athletes.

3. Sprint Force-Velocity Indicators

To better analyse the mechanical capabilities associated with sprinting, sprint trials were used to ascertain theoretical measures of maximum force (F_0), maximum velocity (V_0) and maximum power (P_{max}). These indicators were measured through established validated sprint profiling methods which have demonstrated acceptable to excellent levels of reliability for use with trained athletes.

Pilot Procedures

Five athletes who were part of the larger sport population was done to evaluate whether athletes from other populations could be used as valid subjects for the study. In addition, evaluate the time needed to complete all measurements, to ensure accurate functioning of timing and jump assessment devices, and train personnel who assisted

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with data collection. The pilot trial was also used to standardize the warm-up sequence and recovery times between successive attempts at taking measurements.

The athletes engaged in an 8-week periodized resistance-training program (three times per week) in addition to their normal sprint-specific training. The program was divided into two phases, as follows:

Training Intervention

The athletes completed an 8-week periodized resistance training program, with three sessions per week, in addition to their regular sprint-specific training. The program was divided into two phases:

Phase 1: Strength Development (Weeks 1–4)

This phase emphasized the development of maximal strength using moderate-to-high external loads. The primary exercises included:

- a. Back squat
- b. Romanian deadlift
- c. Walking lunges
- d. Leg press
- e. Hip thrust

Training intensity ranged from 75% to 85% of 1RM, with 3–5 sets of 4–8 repetitions, and rest intervals of 2–3 minutes between sets.

Phase 2: Strength–Power Conversion (Weeks 5–8)

This phase focused on transforming strength gains into sport-specific power and explosive performance. The training program included:

- a. Jump squats
- b. Loaded step-ups
- c. Olympic-lift derivatives
- d. Plyometric drills
- e. Resisted sprint drills

At a range between 40% and 60% of 1RM, explosive training included 3 to 4 set-based training schemes using 3 to 6 repetitions of each lift. Training volume and intent to move maximally for each plyometric exercise were controlled. The sequence of training from maximum-strength emphasis to high-velocity power training follows the periodization of sprint performance development models.

Training Load Control

The research team and sprint coach monitored all training sessions for consistency. The research team took attendance at every training session and adjusted training load for each athlete based on performance and readiness. All athletes received standardized verbal encouragement throughout the entire testing or training process. The goal of this monitored environment was to limit and control training exposure variability while improving adherence to the periodized training plan.

Testing Procedure

Pre-tests for the study were conducted during the week leading up to the intervention. Post-tests were then done within 72 hours after completing the last training session in week 8. All athletic participants who had been part of the training followed a consistent warm-up for all testing days as a part of this process, which included:

- a. 5 minutes of light jogging

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- b. dynamic mobility drills
- c. sprint drills
- d. 2 submaximal practice trials

The testing order was standardized as follows:

- a. Anthropometric measurements
- b. Countermovement jump
- c. 30-m sprint test

A sufficient passive recovery period was provided between tests to minimize fatigue effects.

Statistical Analysis

Data analysis was performed on SPSS to obtain means and standard deviations for each variable. The Shapiro-Wilk test was used to determine if the distribution of the data was normally distributed. The paired-samples t-test was used to calculate comparative scores of pre- and post-test measures. A p-value of less than or equal to 0.05 was pre-defined as statistically significant. Effect size (Cohen's d) was also calculated to evaluate the magnitude of change between pre- and post-measurements. A paired-samples design was utilized to compare within group differences for the strength program's impact on power outputs and sprint performances.

RESEARCH RESULTS

Descriptive Statistics

Table 2. presents the descriptive statistics (Mean \pm SD) for all study variables before and after the 8-week periodized resistance training program.

Table 2. Descriptive statistics for pre- and post-tests

Variable	Unit	Pre-test (Mean \pm SD)	Post-test (Mean \pm SD)	% Change
CMJ Height	cm	41.25 \pm 3.84	46.10 \pm 4.12	+11.76%
Peak Power	W	4520.30 \pm 310.45	4985.60 \pm 335.20	+10.29%
10 m Sprint	s	1.82 \pm 0.08	1.74 \pm 0.07	-4.40%
30 m Sprint	s	4.28 \pm 0.15	4.12 \pm 0.13	-3.74%
F0 (Force)	N	7.35 \pm 0.62	7.90 \pm 0.58	+7.48%
V0 (Velocity)	m/s	8.95 \pm 0.44	9.30 \pm 0.47	+3.91%
Pmax (Power)	W/kg	11.80 \pm 0.72	12.95 \pm 0.80	+9.75%

Inferential Statistics

To determine the significance of differences between pre- and post-tests, a paired-samples t-test was conducted.

Table 3. Paired-samples t-test results

Variable	t-value	p-value	Effect Size (d)	Magnitude
CMJ Height	6.21	0.000	1.38	Large
Peak Power	5.74	0.000	1.25	Large
10 m Sprint	4.98	0.000	1.12	Large
30 m Sprint	5.31	0.000	1.19	Large
F0	4.27	0.001	0.95	Large
V0	3.88	0.001	0.86	Moderate-Large

Pmax	5.46	0.000	1.21	Large
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Results Interpretation

The results revealed statistically significant improvements ($p \leq 0.05$) in all measured variables following the 8-week periodized resistance training program.

The enhancement of lower-body power output as evidenced by the individual improvements demonstrated by each participant's performance on the countermovement jump (+11.76%) and the peak power (+10.29%) has been confirmed through the increase in performance improvements. Therefore, it is reasonable to conclude that the increased lower-body power production experienced is attributable to an increase in neuromuscular efficiency and ability to produce rapid force through a well-structured training program.

In particular, sprint performance has improved markedly as evidenced by an average decrease of 4.40% for 10-metre sprints and an average decrease of 3.74% for 30-metre sprints, which both suggest that participants were able to exhibit better acceleration and maximum velocity. Both of these gains are likely to have resulted from increased force exerted during this training period and an improved rate at which forces were developed.

Also force-velocity profiling factors improved in meaningful manners. The increase in F0 (+7.48%) is indicative of increased capacity to produce force and the increase in V0 (+3.91%) is indicative of increased ability to produce velocity. Therefore, maximal power (Pmax) increased significantly (+9.75%), further confirming the efficacy of the periodized resistance training program to enhance the force-velocity profile.

Effect size analysis revealed large magnitudes for most variables ($d \geq 0.8$), indicating that the observed improvements were not only statistically significant but also practically meaningful.

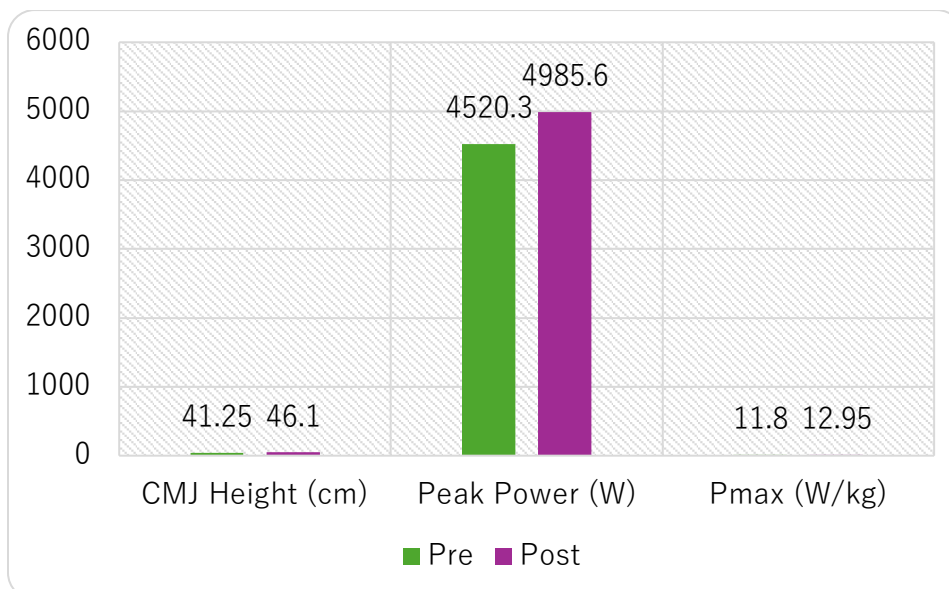


Figure 1. Changes in power output variables (CMJ height, peak power, and Pmax) following the 8-week periodized resistance training program.

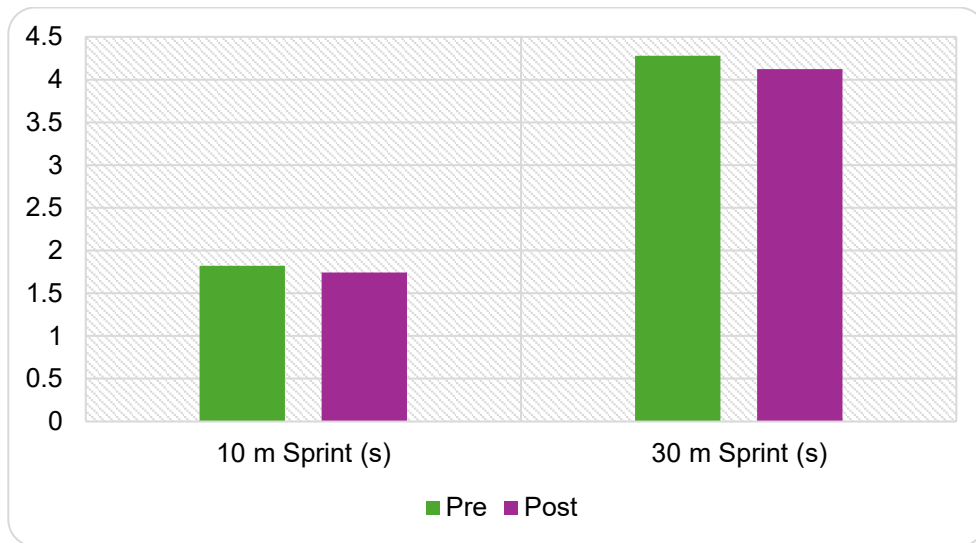


Figure 2. Improvements in sprint performance (10 m and 30 m sprint times) after the training intervention.

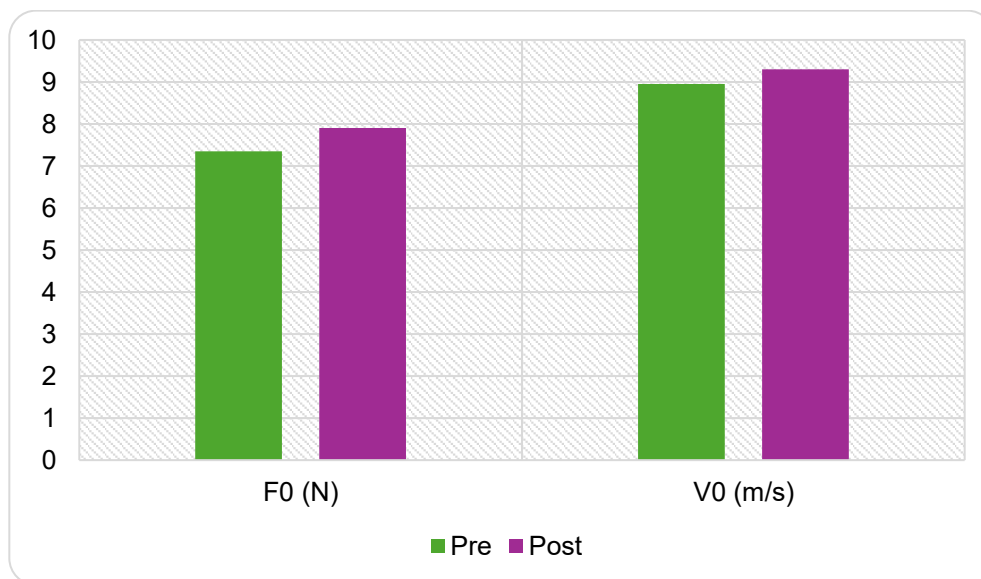


Figure 3. Adaptations in force-velocity profile variables (F0 and V0) following periodized resistance training.

DISCUSSION

The objective of the current research was to analyse how resistance training periodization might influence power output and performance on the sprint track among athletes. After analyzing the data, it was discovered that the treatment group made significant improvements in CMJ height, peak power, sprint performance (10m and 30m) and force-velocity profile variables (F0, V0 and Pmax), thereby indicating that a periodized strategic progressive resistance training programmed can improve both neuromuscular and sprint specific outcomes.

The improvements noticed in the jump height & peak power during the CMJ testing supports the conclusion that the resistance training program of periodized

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training improved lower-body explosive strength in the participants of this study. This is consistent with what has previously been demonstrated by Many researchers, where it is suggested that Resistance Training delivers Improves neuromuscular efficiency through increases in motor unit recruitment, firing frequency and intermuscular coordination (Suchomel et al., 2016). In addition, improvements in CMJ performance have demonstrated the improvement of sprinting performance across numerous studies, particularly in athletes/individuals who exhibit a greater need for quick force production (Loturco et al., 2015a).

The findings of this present study provide evidence of reduced time for both 10 m and 30 m sprints, which indicates enhanced maximum speed of the athletes while getting under (i.e., going through) their maximum velocity at the start of their sprint. Therefore, since the first 10 m phases of sprints are greatly affected by the amount of horizontal force produced to propel oneself forward and the athlete's ability to overcome the initial inertia or being at rest (Morin et al., 2011), the improvement found in this study supports the hypothesis that higher F0 is an indicator of improved acceleration ability, as increased production capacity results in improved acceleration ability of the individual and subsequently to improved overall performance (Morin et al., 2012).

The positive change in performance from the 30 m sprint test indicates that this training program positively affected transitioning to maximal velocity. Sprinting performance is known to be influenced by both the force being produced, mechanics of the stride, and neuromuscular coordination during the entire sprinting process (Haugen et al., 2019). Because of this, the increase in strength and power likely resulted in better sprint mechanics and efficiency when running for the subjects involved in training.

The periodized training program was shown to produce meaningful mechanical adaptations due to the statistically significant increases in force/velocity profile variables (F0, V0, and Pmax). F0 increased as a result of the greater ability of the muscles to generate force, which is crucial during the acceleration phase of running. Based on the results from the study by Samozino and colleagues (2016), this increase in F0, together with the increase in V0 (indicative of increased velocity-focused capabilities), can be attributed to the explosive and plyometric components that were introduced during the later phases of training. Thus, the increase in Pmax represents a more optimal relationship between force and velocity and is considered a key factor influencing sprinting performance (Loturco et al., 2019).

The present study also agrees with other studies that have established the more effective use of periodized resistance training versus non-periodized or other types of unstructured/unsupervised training for improving strength and power performance variables (Hartmann et al., 2015). It is likely that the change from high resistance loading in strength training to power and velocity training improved positive adaptation transfer of the training done in the gym (strength gains) to the athlete's potential for their linear sprint performance (Cormie et al., 2011).

In addition, explosive and plyometric exercises during phase II of the training program may have played a role in the improvement observed. Studies show that plyometric training significantly improves vertical jump and sprint speed, due to improvements in stretch-shortening cycle (SSC) efficiency (Stojanović et al., 2017). Therefore, this supports the conclusion that a combination of resistance training and

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plyometric training within a periodized plan is an effective method to increase sprinting performance.

As per its findings, this study demonstrates that it is important to incorporate resistance training into sprint training programs in a systematic and progressive fashion from a practical standpoint. Current training methods advocate for the alignment of strength and power training with sport-specific requirements in order to optimize performance (Haugen et al., 2019). Results from this study validate the premise that integrating these modalities will produce substantial improvements in both physical and performance variables.

While all the results indicated a benefit, it is crucial to recognize that multiple variables can impact performance when sprinting; some of these include coordination, technique, and muscle stiffness, as well as individual differences among athletes. Several studies have previously demonstrated that strength gains do not always result directly in improved sprinting ability - many factors influence the adaptations and transfer of strength to sprinting ability based on the specifics of both the training and the individual athlete's characteristics (Morin et al, 2011). Therefore, customized training is still essential for creating the best results for each individual.

In conclusion, this study supports the positive impact of periodized weight training on developing explosive strength and improving sprinting speed and activity in track and field athletes. The findings from this research coincide with existing studies on the effectiveness of structured training programs for developing greater sprint performance.

CONCLUSIONS AND RECOMMENDATIONS

The results of this research demonstrate that a periodized resistance training programmed consisting of eight weeks of structured exercise produced greater improvements in lower body power, sprinting speed, and key force-velocity mechanical variables for the track athletes in this study than did not completing the programmed. While the improvements in countermovement jump performance, peak power, and maximum power output (Pmax) were considered substantial neuromuscular adaptations due primarily to increased motor unit recruitment and/or rate of force development, there was also evidence that strength and power improvements transferred successfully to sprinting through significant decreases in 10 m and 30 m sprinting times. The improvements in overall performance - acceleration and maximum velocity phases - were therefore well documented. These improvements (F0 and V0) confirm that an overall improvement in the mechanical profile has occurred (ie, more optimal and balanced profile). These improvements are essential for achieving high-level performance when sprinting. All of these findings demonstrate that periodized resistance training improves both the physiological and biomechanical factors that determine sprinting performance in trained athletes.

Based on these findings, it is recommended that coaches and practitioners systematically integrate periodized resistance training within sprint training programs, ensuring a progressive transition from maximal strength development to explosive power-oriented exercises, in order to maximize performance gains and optimize the transfer of training adaptations to competitive sprint performance.

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