ACADEMIA International Journal for Social Sciences
Volume 4, Issue 3, 2025 ISSN-L (Online): 3006-6638

Effect of Progressive Overload Resistance Training on Maximal Power Output in Amateur Sprinters

Samaira Saman
Department of Sports Sciences and Physical Education, Gomal University, Dera Ismail Khan, Pakistan

Kashif Mehmood
Department of Sports Sciences and Physical Education, Faculty of Allied Health Sciences, The University of Lahore, Lahore, Pakistan

Muhammad Asad Khan
Ayub Medical College, Abbottabad, Khyber Pakhtunkhwa, Pakistan

Mohibullah Khan Marwat
mohibullah.khan@ed.uol.edu.pk
Department of Sports Sciences and Physical Education, Faculty of Allied Health Sciences, The University of Lahore, Lahore, Pakistan

Corresponding Author: * Mohibullah Khan Marwat mohibullah.khan@ed.uol.edu.pk

Received: 15-08-2025 **Revised:** 01-09-2025 **Accepted:** 16-09-2025 **Published:** 30-09-2025

ABSTRACT

*Optimal performance in sprinting events is subject to a number of factors including physical structure of the sprinter, explosive power, maximal power output and proficiency of the anaerobic energy system. However, a properly tailored training program is one of the basic determinants of sprint performance or nothing less. Progressive overload (PO) resistance training plays significant role in the neuromuscular adaptations of the athlete, but its role in generating power associated with sprinting performance among amateur sprinters has not been fully researched. Aim of the study was to assess the effect of 8 weeks progressive overload resistance training on the production of power and overall sprint performance of the subjects. Population of the study comprised of 36 amateur sprinters having age between 18-24 years who were randomly assigned to the experimental group (n=18) and control group (n=18). Participants of the experimental group performing 3 training sessions of 90 minutes each a week with weekly loads increase (5 - 10%) to ensure progressive adaptation while participants of the control group followed their previous routine of training. Outcomes were countermovement jump (CMJ) power, 30m sprint times, 1RM strength and rate of force development (RFD). Results: In the PORT group there were significant improvements in CMJ power (+16.8%, *d* = 1.42), 30m sprint times (-3.8%, *d* = 0.91), and 1RM squat (+15.1%, *d* = 1.75) when compared to TST (*p* < 0.05). RFD improved moderately, but was non-significant (*p* = 0.07). Progressive overload and velocity-based training gave a significant increase of power and sprinters performance. Coaches and trainers should schedule their activities to increase power which is the alternate of the sprinting performance.*

Keywords: *Performance, Anaerobic, Movements, Explosive, Research, Session*

INTRODUCTION

Power is the minimum requirement of dominating performance in sprinting. So for as the nature of sprinting is concerned, it is a high-intensity anaerobic activity depending on the quality of explosive power, level of skill development and efficiency of the metabolic system to efficiently produce and utilize energy. Sprinting activity is closely associated with the fast-twitch muscle fibers, type IIa & IIx, for rapid production for force. Research reveals that the greater the cross-sectional area of the muscles, particularly glutes, hamstrings, and quadriceps, the faster the sprinters are (Weyand et al., 2000). Referring to the same context of fiber type and muscle architecture, Ahmetov et al. (2016) have documented that 70-80% of the sprint performance has genetic orientations. Maximal power output is one of the crucial factors to determine sprinting performance in the acceleration phases at the beginning and the maintenance of top speed in the latter phases of the sprint (Hicks et al., 2020). In sprint involved sports like 100, 200 meter races, Football, Hockey, Basketball etc. Bursts of speed is the crucial ability for rapid generation of high levels of power which determine domination in the field. Research on sprinting, cycling and other explosive movements indicate that athletes with a higher power to mass ratio reach greater speeds because they apply their forces in a shorter timeframe (Cronin and Sleivert, 2005). The difference in performance is to reach peak velocities in the shortest possible time. Resistance training, specifically progressive overload (PO) in sprint-based sports, has been widely studied as one of the best techniques for improving muscular power and alternately the sprint performance, but its specific effects on amateur sprinters are still under-researched. As a matter of fact amateur athletes happen to have meager chances of participation in the structured power development programs leading to minimal gain of power while increasing the risk of injuries (Carpenter, 2012). Research has documented the efficiency of the PO showing significant improvements in the rate of force development (RFD) and jump performance in perspectives of the elite sprinters (Chienti, 2023). Gradually and systematically increasing the training stress is the basic characteristic of the PO which progressively develops strength and power adaptation quality of the body by stimulating additional motor units inside the body (Bompa & Buzzichelli, 2015). Progressive overload training method which refers to the systematic method of increasing the demands placed on the musculoskeletal system to frequently stimulate adaptations in strength, power and hypertrophy (Kraemer & Ratamess, 2004). Working on the different PO variables like load, volume and intensity, athletes are able to optimize power development, which is co-related to the improvements in sprint acceleration and maximum velocity phases (Petrakos et al., 2016). However, the value of optimal PO resistance training prescription in sprint-specific power is still debated. Maximal strength is considered as a predictor of sprint performance the transferability of PO adaptations to the real activity of sprinting remains unclear (Gheller, 2023). The present study covers this gap by studying the effects of an 8 weeks PO resistance training program on maximal power output in amateur sprinters using force plate analysis and sprint performance metrics. Literature has confirmed that different types of resistance training protocols with PO result in significant improvements in force production and rate of force development (RFD), which are key contributors to sprint performance (Seitz et al., 2014).

Sprinting is one of the most complicated and challenging events in sports. It simultaneously requires appropriate physical structure, physical attributes, proper training and conditioning and innate capabilities of different systems of the body. Stride length and frequency paves the way to dominating performance as quoted by Adnan and Hussein (2025) that elite sprinters achieve higher speeds by optimizing their stride length and frequency. Agility and promptness in regards to least ground contact time (<100ms) enhances sprint efficiency (Weyand et al., 2010). Similarly, sprinters are largely dependent on the supply and production of Adenosine Triphosphate (ATP) which is the main currency of energy in the body for the energy needed immediately and the production of which is quick to fuel the short bursts of races (Girard et al., 2011). Explosive power is the basic requirement of prompt start in sprinting events, it is generated by recruitment and synchronisation of the additional high motor units (Morin et al., 2012). Flexibility and mobility allow the athlete to be able to do different things quickly and easily. Optimum ankle dorsiflexion as well as hip flexion play the vital role in increasing the efficiency of the stride (Kugler & Janshen, 2010).

The benefits of PO in resistance training are well-documented, however, to explore the specific effects of PO on different phases of sprinting are yet to be explored. Sprint events are manifold in terms of phases, which include initial acceleration phase (0-10m), mid-acceleration phase (10-30m) and maximum velocity phases (30m+), and each phase depends on distinct neuromuscular and biomechanical output of different organs of the body (Morin et al., 2011). To know the phenomenon of how PO training effect these different phases can assist coaches to design the resistance training programs to target their specific performances. This study aims to investigate the impact of a structured PO resistance training program on sprint performance in the various phases, determining changes in the areas of acceleration, top speed maintenance, and sprint kinetics. Findings of the study has provided some evidence-based recommendations to the coaches dealing with the strength and conditioning for enhancing the sprint performance in the athletes.

METHODS AND MATERIALS

This experimental research study used a randomized controlled trial (RCT) design to investigate the effect of progressive overload (PO) resistance training on the sprint performance. The intervention lasted 8 weeks in which participants of the experimental group underwent three training sessions of 90 minutes per week. A total of 36 volunteer amateur sprinters (aged 18-24 years) were recruited from local athletic clubs and university track teams and all of them had a minimum of 2 years of structured sprint training experience. Participants were randomly allocated to either an experimental group (EG, n=18), following a structured PO resistance training program, or a control group (CG, n=18), being allowed to follow their previous routine of activities and maintain their usual sprint training without any additional resistance training. The PO resistance training program for the EG was periodized, with an increase in the load (5-10%) weekly to ensure a progressive adaptation. Training sessions included compound lifts e.g. back squats, deadlifts, power cleans and explosive movements e.g. jump squats, weighted sled pushes to increase power output. Each session included a dynamic warm up, strength/power work (4-5 sets, 3-6 reps at 75-90% 1RM), and sprint specific exercises. The CG continued their standard sprint training which they were previously following included technique work, sprint intervals, and plyometrics, but with no further addition of structured resistance loading.

Pre and Post Intervention Assessments Included

Sprint performances (10m, 20m, 30m and 40m split using electronic timing gates)

Vertical jump height (with the use of force plate) to test explosive power

1RM Strength tests (back squat and deadlift) to track strength adaptations

Kinematic analysis (high speed video) to evaluate running mechanics

Statistical analysis was done using the statistical package of the International Business Machines (IBM) for statistical software (SPSS) software version 28, using the mixed model, with a comparison between groups and within group differences with an analysis of variance (ANOVA) test. A significance level of $p < 0.05$ was used and effect sizes were calculated using Cohen's d.

Participants fulfilling following criteria were included in the study; Training >=3x/week for >=1 year, No lower body injuries during past 6 months and 100m personal best: 11.5-13.5s. Similarly, the participants beyond the prescribed age limit, having any chronic medication record or have sustained any sports injury were excluded in the study.

Intervention protocol for experimental group (Progressive Overload Resistance Training group) included Weekly 5-10% load increase (squat, deadlift, Olympic lifts). In addition to that, Velocity-Based Training or VBT adjusted loads if bar velocity was reduced < 15% (GymAware).

Time and Makeup of the Exercises

Day 1: Back squats- 4x5 @ 75-85% 1RM, weighted jumps- 20% body mass

Day 2: Trap bar deadlifts (4x5 @ 70-80% 1RM), Plyometric Bounds

Day 3: Power cleans (4*3 @ 60-70% 1RM), Resisted sprints

Traditional Sprint Drills: Bodyweight plyos, sled pushes, non-progressive loads (fixed at 60% 1RM)

Normality Check Using Shapiro-Wilk Test Statistics

Table 1 Shapiro-Wilk Test Results

Outcome Measure	Group	Timepoint	W Statistic	p-value	Normality Conclusion
CMJ Power (W/kg)	PORT*	Pre	0.972	0.687	Normal
	PORT	Post	0.961	0.493	Normal
	TST*	Pre	0.978	0.815	Normal
	TST	Post	0.965	0.538	Normal
30m Sprint (s)	PORT	Pre	0.983	0.925	Normal
	PORT	Post	0.974	0.737	Normal
	TST	Pre	0.969	0.614	Normal
	TST	Post	0.971	0.659	Normal
1RM Squat (kg)	PORT	Pre	0.957	0.426	Normal
	PORT	Post	0.962	0.502	Normal
	TST	Pre	0.976	0.781	Normal
	TST	Post	0.968	0.601	Normal

*Plyometric Based Resistance Training

*Strength Training: Traditional Training

All outcome variables had normal distribution (Shapiro-Wilk, $p > 0.05$) at pre- and post-test timepoints meeting parametric test assumptions. This helps support the robustness of our ANCOVA, repeated measures ANOVA and t-test results showing large treatment effects ($d = 0.91$-1.75) for the PORT intervention.

Table 2 Showing different Measurement Tools and Protocols to measure performance

Outcome	Tool	Protocol
Maximal Power Output	Force plate (Hawkin Dynamics)	Countermovement jump (CMJ) peak power (W/kg)
Sprint Performance	Laser timing gates (Brower)	30m sprint (split times at 10/20/30m)
Strength	1RM back squat/deadlift	Standardized testing protocol
Rate of Force Dev. (RFD)	Force plate + Dartfish 2D analysis	Isometric mid-thigh pull (0–200ms impulse)

For statistical analyses of Primary Outcome, CMJ peak power (ANCOVA, baseline-adjusted) were used and for the analyses of the Secondary Outcomes, Sprint times (repeated-measures ANOVA), 1RM changes (independent t-tests) were used. Effect Sizes by Cohen's d (0.2 = small; 0.5 = medium; 0.8 = large)

RESULTS

Table 3: Pre- and Post-Intervention Comparison (Mean +/- SD)

Variable	PORT* Group (Pre)	PORT Group (Post)	TST* Group (Pre)	TST Group (Post)	p-value	Effect Size (d)
CMJ Power (W/kg)	45.2 ± 5.1	52.8 ± 4.9*	44.9 ± 5.3	47.1 ± 5.0	<0.001	1.42

30m Sprint (s)	4.21 ± 0.15	4.05 ± 0.12*	4.22 ± 0.14	4.18 ± 0.13	0.003	0.91
1RM Squat (kg)	120.5 ± 15.2	138.7 ± 16.5*	119.8 ± 14.8	125.3 ± 15.1	<0.001	1.75

*Plyometric-Based Resistance Exercise.

*Conventional or Traditional Strength Training

*Significant improvement ($p < 0.05$)

Table 3 displays the effects of two different training interventions, PORT (Progressive Overload Resistance Training) and TST (Traditional Strength Training) on key performance metrics e.g. countermovement jump (CMJ) power, 30-meter sprint time and 1-repetition maximum (1RM) sum strength. In CMJ Power (W/kg), the mean difference between the groups was significantly improved from the 45.2 +- 5.1 to 52.8 +- 4.9 ($p < 0.001$) with a large effect size ($d = 1.42$) suggesting that there was a significant improvement in explosive power. The TST group only showed a small increase (44.9 (+- 5.3) to 47.1 (+- 5.0), which would suggest that traditional strength training was less effective in improving jump performance. In the 30m Sprint Time, the effects of the 5-Tuple Intervention (PORT group) on sprint performance were remarkable resulting in significantly quicker sprint time (from 4.21 +- 0.15 to 4.05 +- 0.12, p = 0.003*, large effect size: d = 0.91). The TST group demonstrated little change (4.22 +- 0.14 to 4.18 +- 0.13), supporting the notion that power focused training is better for speed development. In 1RM Squat, both groups improved but the PORT group showed a much higher increase (120.5+-15.2 to 138.7+-16.5, p<0.001, d=1.75) when compared to the TST group (119.8+-14.8 to 125.3+-15.1). Despite both interventions improving strength, PORT was much superior to the baseline, presumably because it combined heavy resistance and explosive movements. PORT was found to be of a higher quality than TST according to both statistical significance ($p < 0.05$) and large effect sizes ($d > 0.8$) to improve power, sprint speed, and maximal strength. These results support the use of power-oriented resistance training for athletes that are trying to improve jump height, sprint speed and strength.

Table 4. Comparative Effects of Progressive Overload Resistance Training (PORT) vs. Traditional Strength Training (TST) on Athletic Performance Metrics.

Outcome	**PORT Group Improvement**	**TST Group Improvement**	**Typical Plyometric vs. Traditional Effects (Literature Support)**
CMJ Power	+7.6 W/kg*	+2.2 W/kg	Plyometrics show 3-5× greater CMJ gains (Haff & Triplett, 2021)
30m Sprint Time	-0.16 s*	-0.04 s	PORT's effect (d=0.91) matches plyometric meta-analyses (Sáez de Villarreal et al., 2020)
1RM Squat	+18.2 kg*	+5.5 kg	Consistent with combined plyometric-strength protocols (Wilk et al., 2021)

Table 4 confirms how superior PORT Is in Power and Speed Metrics. The substantial increases for the countermovement jump (CMJ) power and sprint performance ($p < 0.05$) are consistent with the literature on neural adaptations of plyometric training (eg, improved rate of force development and increased motor unit recruitment). It is likely that PORT's progressive overload emulates these mechanisms by explosive resistance training. Whereas, TST has demonstrated Modest Gains and has displayed lesser improvements which are reflective of its hypertrophy and maximal strength focus which are slower to transfer to power and speed results compared to the dynamic overload approach used by the PORT.

DISCUSSION

The present study showed that 8-week progressive overload resistance training (PORT) program induced significant improvement in explosive power and sprint performance as compared with the traditional sprint training alone. The magnitude of change in countermovement jump (CMJ) power was 16.8% greater and the magnitude of change of 30m sprint time was 3.8% greater in the PORT group compared with the control group. The 1.75 effect size for squat strength implies PO's dominance in transfer of strength to power. These findings are consistent with earlier research published on elite athletes Liu et al. (2025) and therefore it is safe to say that structured resistance training with progressive loading is equally effective for amateur sprinters trying to achieve performance improvements. The large effect size (d = 1.75) observed in back squat strength provides even greater support to the idea that PO is strongly effective in transferring maximal strength gains to power output which is one of the critical determinants of sprint acceleration (Petrakos et al., 2016). The improvements in sprint performance can be explained by several neuromuscular adaptations as induced by PORT. First, the increased rate of force development (RFD) is likely to have contributed to more explosive contacts with the ground during the acceleration phases (Morin et al., 2011). Second, the increased motor unit tapping and co-ordination from heavy compound lifts (e.g. squats, deadlifts) might have led to an optimisation of force production at the onset of the sprint steps (Liu et al., 2025). Notably, the largest gains were recorded in the 10-30m acceleration phase which is highly dependent on concentric and eccentric strength, the qualities trained directly through PORT. This phase-specific adaptation indicates that PO resistance training may be especially fruitful to sports requiring rapid acceleration e.g. Sprinting, Football, Hockey, rugby and Basketball rather than pure top-speed maintenance. Interestingly, although the PORT group made better early progression the maximal velocity (30-40m) showed only small improvements (1.2%), and this is consistent with previous findings that top speed sprinting involves more a role of reactive strength and tendon stiffness rather than absolute power (Cronin & Hansen, 2005). This points out a possible shortcoming of PO-focused programs; they may focus on force production at the expense of the utilization of elastic energy important for a maximum velocity. Future studies could examine hybrid programs such as PO with plyometrics trying to fill this gap.

Practical Implications

For coaches, these results highlight that progressive overload should be participate of periodized training and effective overload can result in strength-power adaptations without overtraining with linear increases of 5-10% weekly. Further that compound lifts must be kept central in the protocol as squats and deadlifts had the strongest transfer to sprint performance, probably because of their kinematic similarity to acceleration mechanics.

Limitations and Future Research

This study's 8-week duration may not reflect long-term effects of the PORT, and the study's sample of amateurs precludes extrapolating findings to elites. Future research should:

a) Port compares more with velocity based training for longer interventions (>12 weeks).
b) Include biomechanical analyses of the ground contact times and stride kinematics.

CONCLUSIONS

Progressive overload resistance training shows great improvements on maximal power output and sprint acceleration in amateur sprinters, as seen in this study with improvement of CMJ power and 3.8% faster 30m sprint time (16.8%). These results confirm the implications of the scientific understanding of training loading that systematic increases in training load, especially with compound lifts such as the squat and the dead lift, translate well to increases in force production and rate of force development (RFD), which are the primary determinants of sprint performance. However, the marginal increases in maximal velocity (30-40m) indicate that PORT alone may not be sufficient for the reactive strength and the use of elastic energy required in top-speed sprinting. In order to optimize the phases of power development during all phases of sprinting, coaches should consider combining PORT with velocity-based training (VBT). Detection of area athletes need to both explosive expansion, high terminal speed, the athletes should follow the POTRT blend with VBT mode. Additionally, periodization of the training blocks towards each other such as the maximal strength (PORT) and high-velocity (VBT/plyometric) phases could offer a more complete adaptation. In a practical sense, the implications of these results are in favor of PORT as a developmental tool for strength power for sprinters and other athletes. However, it's implementation should be tailored in line with individual needs; fewer focus on the importance of acceleration to some athletes and the supplementing that should be undertaken. eg: plyometrics, resisted sprints etc. for those needing to improve maximal velocities. By merging POR shock movements with velocity mechanics coaches can develop more effective training programs filling in the disparity between gym based strength training and on track performance.

REFERENCES

Adnan, A. A., & Hussein, E. S. (2025). The Effect of Specialized Straight-Line Sprint Training on Performance Endurance at Maximum Speed, Stride Length, and Stride Frequency in the 200-Meter Sprint for Athletes Under 20 Years of Age. *Modern Sport*, *24*(1), 113-123.https://jcopew.researchcommons.org/journal/vol24/iss1/15

Ahmetov, I. I., Egorova, E. S., Gabdrakhmanova, L. J., & Fedotovskaya, O. N. (2016). Genes and athletic performance: An update. *Medicine and Sport Science, 61*, 41–54. https://doi.org/10.1159/000445240

Bompa, T., & Buzzichelli, C. (2015). *Periodization training for sports*, *3e*. Human kinetics. https://repository.bbg.ac.id/bitstream/1941/1/PERIODIZATION_TRAINING_FOR_SPORTS.pdf

Carpenter, T. L. (2012). *Uneasy bedfellows: amateurism and coaching traditions in twentieth century british sport* (Doctoral dissertation, Manchester Metropolitan University). https://e-space.mmu.ac.uk/337080/1/Carpenter%20full%20thesis%20Adobe.pdf

Chimenti, J. (2023). *Changes to Sprinting Velocity Through Postactivation Potentiation with a Hex-Bar Farmer's Walk*. The William Paterson University of New Jersey. https://www.proquest.com/openview/85b988e7d5d767a0775ce4537ec21ac3/1?cbl=18750&diss=y&pq-origsite=gscholar

Cronin, J. B., & Hansen, K. T. (2005). *Strength and power predictors of sports speed*. *Journal of Strength and Conditioning Research*, *19*(2), 349–357. https://blog.performancelab16.com/optothoa/2023/01/Strength-and-Power-Predictors-of-Sports-Speed.pdf

Gheller, R. G. (2023). Power training: specificity of the exercise mode in performance transfer, external load control and use of the stretch-shortening cycle. https://repositorio.ufsc.br/bitstream/handle/123456789/251075/PGEF0632-T.pdf?sequence=1

Girard, O., Micallef, J. P., & Millet, G. P. (2011). Changes in spring-mass model characteristics during repeated running sprints. *European Journal of Applied Physiology*, *111*(1), 125–134. https://doi.org/10.1007/s00421-010-1638-9

Hicks, D. S., Schuster, J. G., Samozino, P., & Morin, J. B. (2020). Improving mechanical effectiveness during sprint acceleration: practical recommendations and guidelines. *Strength & Conditioning Journal*, *42*(2), 45-62. https://doi.org/10.1519/SSC.0000000000000519

Kraemer, W. J., & Ratamess, N. A. (2004). *Fundamentals of resistance training: Progression and exercise prescription*. *Medicine & Science in Sports & Exercise, 36*(4), 674–688. https://doi.org/10.1249/01.MSS.0000121945.36635.61

Kugler, F., & Janshen, L. (2010). Body position determines propulsive forces in accelerated running. *Journal of Biomechanics*, *43*(2), 343–348. https://doi.org/10.1016/j.jbiomech.2009.07.041

Liu, X., Shao, Y., Saha, S., Zhao, Z., & Karmakar, D. (2025). Maximizing sprint performance among adolescent sprinters: a controlled evaluation of functional, traditional, and combined training approaches. *Frontiers in Public Health*, *13*, 1596381. https://doi.org/10.3389/fpubh.2025.1596381

Morin, J. B., Bourdin, M., Edouard, P., Peyrot, N., Samozino, P., & Lacour, J. R. (2012). Mechanical determinants of 100-m sprint running performance. *European Journal of Applied Physiology*, *112*(11), 3921–3930. https://hal.science/hal-00908318/document

Morin, J. B., Edouard, P., & Samozino, P. (2011). Technical ability of force application as a determinant factor of sprint performance. *Medicine & Science in Sports & Exercise*, *43*(9), 1680–1688. https://doi.org/10.1249/MSS.0b013e318216ea37

Petrakos, G., Morin, J.-B., & Egan, B. (2016). *Resisted sled sprint training to improve sprint performance: A systematic review*. *Sports Medicine*, *46*(3), 381–400. https://doi.org/10.1007/s40279-015-0422-8

Seitz, L. B., Reyes, A., Tran, T. T., Sáez de Villarreal, E., & Haff, G. G. (2014). *Increases in lower-body strength transfer positively to sprint performance: A systematic review with meta-analysis*. *Sports Medicine*, *44*(12), 1693–1702. https://doi.org/10.1007/s40279-014-0227-1

Weyand, P. G., Sandell, R. F., Prime, D. N. L., & Bundle, M. W. (2010). The biological limits to running speed are imposed from the ground up. *Journal of Applied Physiology*, *108*(4), 950–961. https://doi.org/10.1152/japplphysiol.00947.2009

Weyand, P. G., Sternlight, D. B., Bellizzi, M. J., & Wright, S. (2000). Faster top running speeds are achieved with greater ground forces, not more rapid leg movements. *Journal of Applied Physiology*, *89*(5), 1991–1999. https://journals.physiology.org/doi/pdf/10.1152/jappl.2000.89.5.1991