International Journal of Strength and Conditioning

Godwin, M. S., Dhone, S., & Newman, M. A. (2023). Post-Activation Performance Enhancement (PAPE) After Resisted Sprinting in Recreationally Active Participants: A Double-Blind Randomised Crossover Trial.
International Journal of Strength and Conditioning
https://doi.org/10.47206/ijsc.v3i1.226

Post-Activation Performance Enhancement (PAPE) After Resisted Sprinting in Recreationally Active Participants: A Double-Blind Randomised Crossover Trial

Mark S. Godwin[1], Sahil Dhone[2], & Mark A. Newman[2]

[1]School of Health, Sport and Food, University College Birmingham, Moss House, 3 Holland Street, Birmingham B3 1QH, UK, [2]Department of Sport and Nutrition, School of Health, Sport and Food, University College Birmingham, Moss House, 3 Holland Street, Birmingham B3 1QH, UK.
Corresponding Author: markgodwin705@gmail.com

ABSTRACT

Sprint performance and therefore sprint training play important roles in a range of sports and numerous methods to enhance sprint performance have been proposed. One such method is resisted sprinting, whereby a predetermined load (% body mass) or a load which elicits a reduction in sprint velocity, is towed over a prescribed distance. Resisted sprint training can be implemented chronically or acutely. The latter is used to elicit a performance enhancement via post-activation potentiation whereby a superior performance may be achieved when the activity is preceded by a specific stimulus, usually as part of the warm up. The purpose of this study was to determine if a post-activation performance enhancement (PAPE) could be achieved following an acute resisted sprint at two different decreases in sprint velocity using novel resisted sprint equipment (Run Rocket). Eleven healthy male, recreationally trained volunteers (age 23.4 ± 1.9 years, height 180.5 ± 3.5 cm, body mass 86.4 ± 14.5 kg) participated in the study. A maximal 15 m baseline body mass only sprint was performed on the initial visit to ascertain 5 and 15 m sprint time. Participants visited a further two times which consisted of a pre-conditioning resisted sprint activity using the Run Rocket at two different resistance settings in a randomised counter-balanced design. A repeated measures analysis of variance (rmANOVA) showed no significant differences in sprint time, velocity or acceleration between the three conditions ($p > 0.05$). However, when assessing individuals by the smallest worthwhile change, some participants may have decreased their sprint time. Therefore, the use of resisted sprints did not elicit a post-activation performance enhancement in recreationally trained individuals and may not be beneficial for augmenting acute performance in this population. Individual responses to this type of training may vary and should be a consideration for strength coaches.

INTRODUCTION

Sprint performance may play a role in the successful outcome of certain sports. Aside from track athletes where the first to cross the line denotes success, linear sprinting in field sports is also an important factor (Wong et al., 2017). Sprinting therefore, plays a role in the development and outcomes across individual and team sports such as athletics, American football, basketball and field hockey (Alcaraz et al., 2018). In soccer for example, the development of physical capabilities, along with technical and tactical skills, are also required (Haugen et al., 2014). Sprinting is one such capability that plays a decisive role in winning aspects of soccer such as 1 on 1 duels or creating gaps between attackers and defenders (Haugen et al., 2014). A recent review by Beato and colleagues discussed the implementation of sprint training in professional soccer from performance and injury prevention perspectives (Beato, Drust and Iacono, 2021). Similarly in professional rugby, acceleration and high-speed ability is a component of success (Cunningham et al., 2013). Sprint time has also been shown to discriminate between levels of athletes in handball where elite players displayed showed significantly less time for 0-10 m and 0-20 m, compared with under 18 and under 16 (Ortega-Becerra et al., 2018). Kaplan, Erkmen and Taskin (2009) also showed differences between playing level in soccer. In a 10 x 5 m shuttle running test, professional players demonstrated quicker performances compares to amateur, however no differences were found across playing position (Kaplan, Erkmen and Taskin, 2009). However, in Division I collegiate female soccer players, Lockie et al. (2018) did report significant differences in sprint time between player positions, where midfielders had a faster time compared with the defenders and goalkeepers over the short 5 m sprint. Therefore, training methods to increase acceleration and velocity are incorporated into programmes across a spectrum of sports and athletes and has been described as a central training goal for conditioning coaches (Petrakos, Egan and Morin, 2016).

Resisted sprint training is one such method used to improve sprint performance, but a systematic review of longitudinal studies has been inconclusive when compared to unresisted sprint training (Petrakos, Egan and Morin, 2016). The duration of the studies included in the review ranged between 4 to10 weeks, with participants ranging from recreationally active males and females to professional male rugby players (Zafeiridis et al., 2005; Harrison and Bourke, 2009). In a more recent systematic review, Alcaraz et al. (2018) showed an overall significant improvement in the acceleration phase of 15 studies (144 participants) post resisted sprint intervention (p = 0.0001, ES 0.61, SMD 0.57, 95% CI -0.85 to -0.28). Similar to the Petrakos, Egan and Morin (2016) review, the duration of the sprint training ranged between 4 and 10 weeks. However, when compared to a control group, a non-significant improvement was found. A non-significant improvement for the maximum velocity phase (81 participants) was also found. Results from the full pre versus post sprint distance (10-50 m) were significant ($p \leq 0.05$, SMD 0.38, 95% CI -0.67 to -0.10) with non-significant improvements when compared to a control group. Overall, resisted sprint training may be effective for the early acceleration phase of the sprint, but it is unclear if the effects are superior to sprint training without the overload (Alcaraz et al., 2018). Despite the inconclusive results of these longitudinal studies, resisted sprint training has been incorporated in individual sessions as a conditioning contraction to enhance subsequent performance. Early work reported that post-activation potentiation (PAP) is an increase in muscle twitch following a contractile activity from several methods: (1) series of evoked twitches (treppe), (2) evoked tetanic contraction or, (3) a sustained maximal voluntary contraction (MVC) (Sale, 2002). The underpinning mechanism for this was associated with an increase in the phosphorylation of the myosin light chain, that subsequently increased the rate of force development by an increase in cross-bridge formation (Blazevich and Babault, 2019). This mechanistic approach should not be used to describe the performance approach when voluntary contractions are used instead of electrical stimulation (Prieske et al., 2020). Furthermore, when the effects of a conditioning contraction are measured by performance outcomes e.g., maximal strength, jump and sprint performance, the term post-activation performance enhancement (PAPE) should be used (Blazevich and Babault, 2019; Prieske et al., 2020). Whilst PAP may influence PAPE, possibly in the early part of the performance, other mechanisms have been suggested to explain the latter. Blazevich and Babault (2019) propose muscle temperature, muscle and muscle fibre water content, and muscle activation as potentiation mechanisms and suggest that PAPE is inhibited by fatigue and motor pattern interference.

Similar to the longitudinal studies, the acute potentiating effects of resisted sprinting on subsequent sprint performance yields inconclusive results. In elite female sprinters, PAPE was evident following a single resisted sprint of 10% body mass over a 20 m distance from a standing start (ES -0.64, 95% CI -1.51 to -0.29) compared to loads of 5 and 15% of body mass (Matusiński et al., 2021). In a similar study using international and national level male and female sprinters, Matusiński et al. (2022) reported significant decreases in 10 and 50 m sprint time following 3 x 30 m resisted sprints at 10% body mass compared to baseline (male 10 m and 50 m, $p = 0.002$, $\eta^2 = 0.25$ and $p = 0.001$, $\eta^2 = 0.45$; female 10 m and 50 m, $p = 0.002$, $\eta^2 = 0.20$ and $p = 0.001$, $\eta^2 = 0.29$). Using the same equipment to provide the sprint resistance as the two previous studies (1080 Sprint device), Thompson et al. (2021) showed no significant differences in sprint performance over 20 m. However, the varsity level sprinters were exposed to a load of ~45% of body mass and performed three resisted sprints prior to the final unresisted sprint. When using sprint velocity decrement (V_{dec}) to prescribe the resisted sprint load, both Cochrane and Monaghan (2021) and Williams, Baghurst and Cahill (2021) showed significant improvements in performance of male rugby players and high school football players (age range 16-18 years), respectively. Implementing a single resisted sprint equal to a V_{dec} of 35 or 55% on a synthetic surface (4 mm carpet), Cochrane and Monaghan (2021) showed significant decreases in subsequent sprint velocity at 12 and 16 minutes post conditioning activity for both sled loads. There were no differences at the earlier timepoints (2, 4, 6, and 8 min). The lighter of the two conditioning activities (35% V_{dec}) improved velocity at 20 m compared to the heavier load with no other differences at other distances (5, 10 and 15 m). Similarly, improvements in performance were seen when a V_{dec} of 40-50% (66-70% body mass) was used for three 15 m conditioning sprints followed by an unresisted sprint (Williams, Baghurst and Cahill, 2021). A significant mean difference (0.1 s) between peak baseline and post conditioning sprints over the 15 m was observed ($p < 0.001$, Cohen's $d = 0.92$). The potentiating sprints were conducted indoors on artificial turf. Currently, the prescription of an optimal load for sprint performance has yet to be established (Zabaloy et al., 2023). Despite this, sled training is used as a secondary method to provide a stimulus via minimal overload (Alcaraz et al., 2018).

One problem with using sleds and subsequent loading based on a percentage of body mass is the inability to account for the surface friction. The speed of the sled is affected by the interaction with the surface and may pose issues when prescribing loads (Williams, Baghurst and Cahill, 2021). The Run Rocket is a resisted sprint machine which has a nylon cord wrapped around a mechanically braked flywheel. The resistance is not influenced by surface friction and has been shown to have high intra and intersession reliability with recreationally active participants (ICC > .79) (Godwin et al., 2020). Although there is some literature relating to the use of resisted sprinting to acutely enhance performance, to date the Run Rocket has not been studied. Therefore, the aim of this study was to investigate the use of this equipment as a conditioning activity to induce PAPE in recreationally trained participants over a short sprint (15 m) using two different resistance settings (RR0 and RR5). The primary outcome was sprint time over 15 m, with additional outcomes of velocity and acceleration at 5 and 15 m. In order to maximise the practical application of this type of intervention and increase the external validity, a complete warm up for both conditions was implemented (Blazevich and Babault, 2019).

METHODS

Participants

Eleven male university sports students participated in a double-blind crossover study to investigate the potentiating effects of the Run Rocket on 5 and 15 m sprint performance (age 23.4 ± 1.9 years, height 180.5 ± 3.5 cm, body mass 86.4 ± 14.5 kg). For inclusion, all participants met the following criteria: (a) injury-free; (b) minimum one year of engagement in recreational sporting or physical activity. Participants were excluded if they (a) any past/present injury that could potentially affect sprint performance; (b) less than a year of engagement in any form of sporting or physical recreational activity. The study protocol was approved by the institutional research and ethics committee and subsequently conducted in accordance with the Declaration of Helsinki. Before any testing took place, each participant completed a physical activity readiness questionnaire (PAR-Q) and gave written informed consent.

Study design

A double-blind randomised crossover design was used to test whether resisted sprinting using a commercially available sprint machine (Run Rocket, San Antonio, Texas, USA) could elicit PAPE on 5 and 15 m sprint performance (sprint time, velocity and acceleration). The resistance of the Run Rocket was set to 0 and 5 on the digital display which had previously been used in a reliability trial (Godwin et al., 2020). Based on this previous study, it was hypothesised that the chosen resistance would equate to a decrease in velocity seen in other studies to allow for comparison. The participants completed 3 sessions, separated by 7 days. In the first session, a baseline 15 m unresisted sprint time was established along with familiarisation of the equipment. All the testing took place indoors on a synthetic track at the same time of day in a temperature-controlled environment (20°C). Participants were required to wear the same footwear for each testing session, refrain from ingesting caffeinated products 24 hr prior, maintain their regular dietary habits before each session and refrain from any fatiguing exercise 48 hr before the testing.

Procedures

Before each testing session, participants undertook a standardised dynamic warm up (FIFA 11+). Briefly, this consisted of submaximal running, dynamic movements, and finished with 2 sets of 20 m sprints of increasing intensity (75 and 90% of self-selected sprint speed). The first session was used to familiarise the participants with the testing procedures, the Run Rocket , and establish a baseline unresisted 15 m sprint time. Participants were randomised into two equal groups for subsequent testing based on the two resistance settings (RR0 or RR5). Following the dynamic warm up, participants completed 2 maximal 15 m sprints to establish their best time. Each sprint was started in a two-point stance with their lead foot 5 cm behind the first set of timing gates (Witty GATE, Microgate Italy, Bolzano, Italy). The timing gates were placed at 0, 5 and 15 m. On the second and third session participants undertook the same warm up with the addition of 3 resisted sprints using the Run Rocket (conditioning contractions) at either RR0 or RR5 with 6 minutes intra-set recovery This was followed 8 minutes later by 2 unresisted 15 m sprints with 3 minutes intra-set recovery (Figure 1).

The Run Rocket was attached to the participant via the adjustable shoulder harness which was fixed to the nylon cord by a D-ring. The D-ring was placed approximately midway between the medial borders of the scapulae and the harness tightened using the waist strap. Mechanical resistance was set using the adjustable knob that was blind to the lead researcher and the participants.

Statistical analysis

Results were initially collated in Microsoft Excel (2018). Statistical analysis was conducted in SPSS (IBM SPSS Statistics for Windows, Version 28.0.0.0). Dependent variables were presented as mean ± standard deviation. A repeated measures ANOVA was used to assess within subjects effects with a significance level of 0.05. Effect size was calculated as generalised eta squared (η^2G). Mauchly's test of sphericity was used to show if the variances of the differences between the conditions were equal. Confidence intervals (95%) were also calculated for each condition. Intraclass correlation coeffcient using two-way mixed effects, average measures and absolute agreement of the preconditioning resisted sprints was measured using the three trials from RR0 and RR5 over 5 m (Koo and Li, 2016). In addition to null-hypothesis testing, the coefficient of variation (CV) and the smallest worthwhile change (SWC) in sprint performance were also calculated for 5 and 15 m sprints using group SD*0.2.

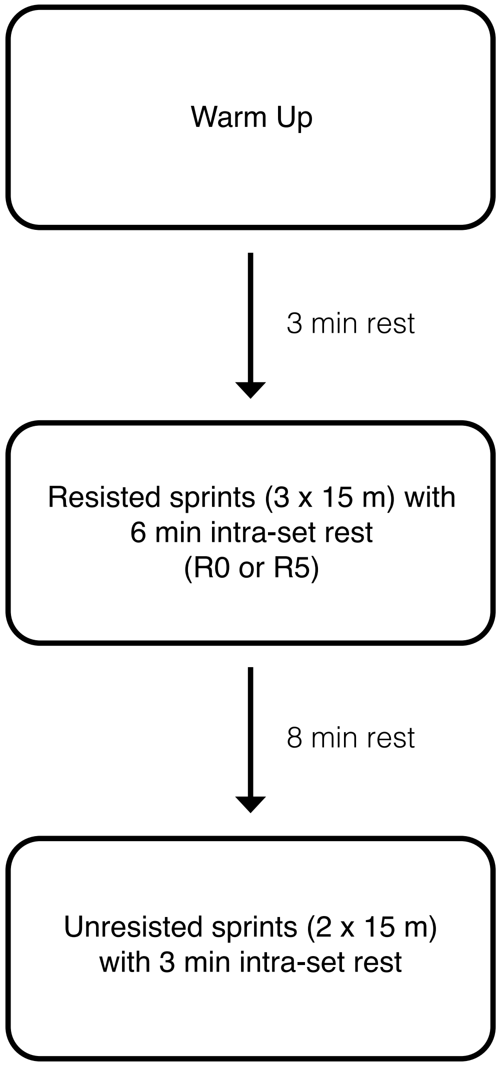

Figure 1. Schematic representation of the resisted sprint protocol.

RESULTS

The intraclass coefficient between the three resisted trials, based on 5m sprint time, was .950 (95% CI .868, .984) and .945 (95% CI .853, .983) for RR0 and RR5 respectively. The resisted sprints equated to a velocity loss of 18.1% ± 5 for resistance zero and 40.4% ± 6.1 for resistance 5. Sphericity was not violated and the results of the repeated measures ANOVA showed no differences between each condition for sprint time 5 m, F (2, 20) = 0.54, p = .54, η^2G = .02; sprint time 15 m, F (2, 20) = 0.04, p = .95, η^2G = .001; velocity 5 m, F (2, 20) = 0.46, p = .63, η^2G = .02; velocity 15 m, F (2, 20) = 0.05, p = .95,

η^2G = .001; acceleration 5 m, F (2, 20) = 0.44, *p* = .66, η^2G = .02; acceleration 15 m, F (2, 20) = 0.06, *p* = .94, η^2G = .002 (Table 1). Individual changes in performance compared to baseline for RR0 and RR5 at 5 m and 15 m are shown in Figures 5 and 6, respectively. The CV was 3% for 5 and 15 m and the SWC for 5 and 15 m were 0.02 and 0.03 s, respectively. The results showed individualised responses at both distances for both loads. Over the 5 m split, 6 of the participants' scores were greater than the SWC and may be considered relevant for RR0 and RR5. For the 15 m sprint, 4 scores were greater than the SWC for RR0 and 5 for RR5.

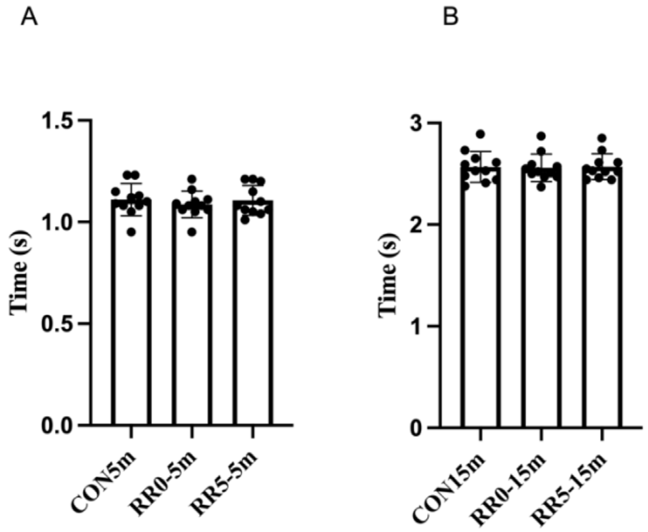

Figure 2. Sprint time (s) for 5m (A) and 15m (B) between each condition (CON – unresisted; RR0 – resistance 0; RR5 – resistance 5). No difference between conditions (*p* > 0.05).

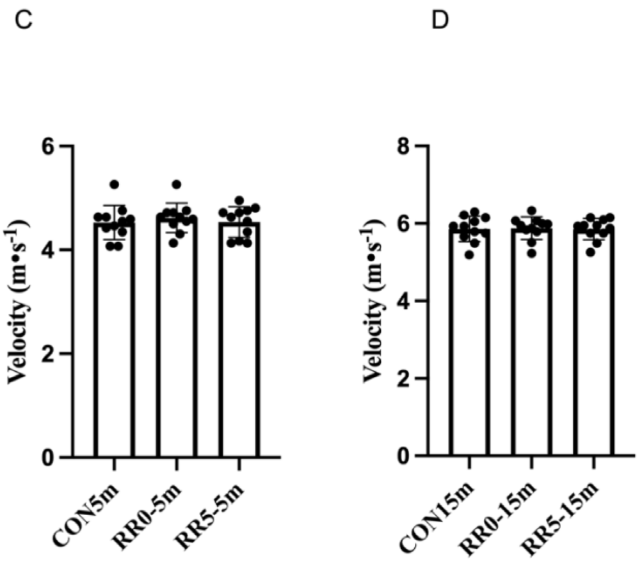

Figure 3. Velocity (m•s^{-1}) for 5m (C) and 15m (D) between each condition. No difference between conditions (p > 0.05).

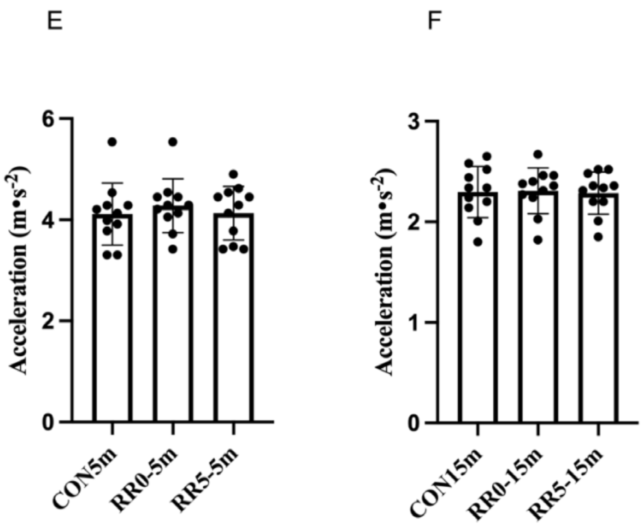

Figure 4. Acceleration (m•s^{-2}) for 5m (E) and 15m (F) between each condition. No difference between conditions (*p* > 0.05).

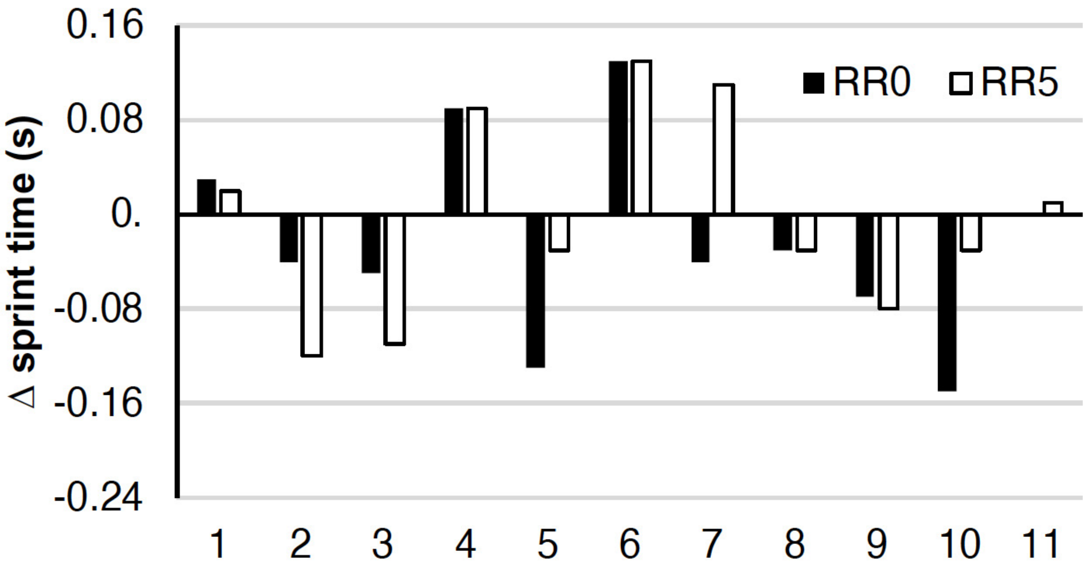

Figure 5. Individual delta 5 m sprint time compared to baseline (RR0 and RR5).

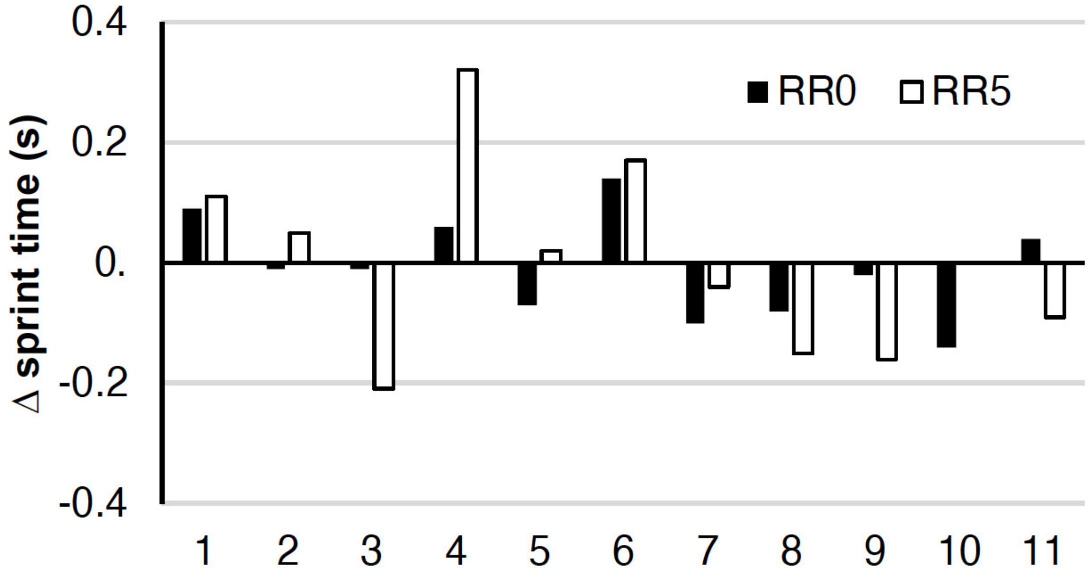

Figure 6. Individual delta 15 m sprint time compared to baseline (RR0 and RR5).

Table 1. Sprint time (s), velocity ($m \cdot s^{-1}$) and acceleration ($m \cdot s^{-2}$) for 5 and 15 m (Mean ± SD and 95% CI).

	5 m			15m		
	CON	**RR0**	**RR5**	**CON**	**RR0**	**RR5**
Sprint time (s)	1.11 ± 0.08 (1.06, 1.16)	1.09 ± 0.07 (1.04, 1.13)	1.11 ± 0.07 (1.06, 1.16)	2.57 ± 0.15 (2.47, 2.67)	2.56 ± 0.14 (2.47, 2.65)	2.57 ± 0.13 (2.48, 2.65)
Velocity ($m \cdot s^{-1}$)	4.53 ± 0.33 (4.31, 4.75)	4.62 ± 0.28 (4.43, 4.81)	4.54 ± 0.29 (4.34, 4.74)	5.64 ± 0.33 (5.64, 6.08)	5.88 ± 0.30 (5.68, 6.08)	5.85 ± 0.28 (5.67, 6.04)
Acceleration ($m \cdot s^{-2}$)	4.12 ± 0.61 (3.70, 4.53)	4.28 ± 0.53 (3.92, 4.64)	4.13 ± 0.53 (3.78, 4.49)	2.30 ± 0.25 (2.13, 2.47	2.31 ± 0.23 (2.16, 2.46)	2.29 ± 0.21 (2.15, 2.43)

(CON – unresisted; RR0 – Run Rocket resistance zero; RR5 – Run Rocket resistance 5).

DISCUSSION

The aim of this study was to examine the effects of resisted sprints, as a conditioning activity, on subsequent 15 m sprint performance. The two resistance settings elicited a velocity decrement (V_{dec}) of 18.1% ± 5 and 40.4% ± 6.1 (RR0 and RR5, respectively). This range has been used in acute studies which showed significant increases in sprint performance for rugby and soccer athletes e.g., Williams et al. (2021); Cochrane and Monaghan (2021). The velocity at 5 m also falls into the range of optimal peak power for recreational mixed-sport athletes and sprinters (4.19 ± 0.19 and 4.90 ± 0.18 m•s^{-1}) (Cross et al., 2018). However, the results from this study showed no differences in sprint time between each condition. Similarly, no significant differences were seen for velocity or acceleration between all three conditions at the two distances. These results are in line with previous resisted sprint PAPE studies which reported no differences in sprint performance following acute preconditioning resisted sprint activity (Whelan, O'Regan and Harrison, 2014; Mangine et al., 2018; Van Den Tillaar, Teixeira and Marinho, 2018; Thompson et al., 2021).

Resisted sprint studies that have shown no differences in acute sprint performance have used loads ranging between 5 and ~45% of body mass (Whelan, O'Regan and Harrison, 2014; Mangine et al., 2018; Van Den Tillaar, Teixeira and Marinho, 2018; Thompson et al., 2021). In their study using a single resisted sprint, equivalent to 5% body mass, Mangine et al. (2018) reported no effect on subsequent 20 m sprint performance. The 5% load was sufficient to cause a significant increase in sprint time at the 15 and 20 m distances along with significant decreases in velocity for the conditioning activity. The mean V_{dec} was ~4 and 7% for 15 and 20 m. This decrease in velocity is less than the current study. They did, however, show that the single resisted sprint increased the rate of force development in the final unresisted sprint at 20 m, with all other distances showing no difference. Using three resisted sprints equivalent to 25-30% body mass, followed by 6 x 10 m sprints (1, 2, 4, 6, 8 and 10 min), Whelan, O'Regan and Harrison (2014) reported inconsistent patterns of PAPE in the 12 participants. Overall, there were higher occurrences of fatiguing events compared to PAPE events across reactive strength index and stride length, whilst the reverse was the case for contact time, velocity and step rate. A heavier preconditioning load of ~45% body mass was used by Thompson et al. (2021) in their study with varsity-level sprinters. A single unresisted sprint, followed by three resisted sprints showed no performance enhancement in a final single 20 m sprint. These non-significant findings support the suggestion that post-activation performance enhancement may be highly individual and depend on numerous factors (Seitz and Haff, 2016). Individual responses to the conditioning activity from the current study may also support this (Figure 5 and 6). Furthermore, when using SWC to monitor changes in performance, the results from this study were individualised. In the 5 m split, 55% of the population exceeded the SWC for both loads. In the 15 m sprint, 36% and 45% exceeded it for RR0 and RR5, respectively.

Studies that found significant increases in performance used similar loads to those reporting no differences in sprint performance (10-150% body mass) (Smith et al., 2014; Winwood et al., 2016; WONG et al., 2017; Cochrane and Monaghan, 2021; Matusiński et al., 2021, 2022; Williams et al., 2021; Chomentowski III et al., 2022; Zisi et al., 2022). In addition to the loads falling in the same range as the non-significant studies, except for the heavy sled pull study (Winwood et al., 2016), the populations used were equally diverse. Williams et al. (2021), Chomentowski III et al. (2022) and Zisi et al. (2022) studied a younger athletic population with the load being provided via a loaded sled over 15 m, 15 yd and 20 m distances, respectively. Like the current study, they used multiple resisted sprints as the conditioning activity. These ranged between 2 x 20 m, 4 x 15 yd and 3 x 15 m, all with 2 min rest between sprints (Williams et al., 2021; Chomentowski III et al., 2022; Zisi et al., 2022). Other studies that reported potentiating effects following resisted sprints used participants from recreationally trained and anaerobically trained (Smith et al., 2014; Wong et al., 2017), experienced club rugby and premier club rugby (Winwood et al., 2016; Cochrane and Monaghan, 2021), and elite sprinters (Matusiński et al., 2021, 2022). Despite differences in protocols e.g., a single resisted sprint with 10% body mass versus 75% body mass (Winwood et al., 2016; Matusiński et al., 2021), there may be a balance of PAPE between two factors: fatigue and the potentiation effect of the external load (Mangine et al., 2018). The effect of fatigue may therefore be linked to the strength level of the participants. This appears to be supported in the studies where PAPE was observed.

A greater PAPE may be achieved by stronger athletes with less recovery (5-7 min) than weaker individuals (>8 min) (Seitz and Haff, 2016). The use of 6 minutes between each resisted sprint may have impacted the potentiating effect in our population, although rest periods of longer duration have been shown to be effective following conditioning activities (Seitz and Haff, 2016). The current study also implemented 8 minutes of rest prior to the final unresisted sprints. Shorter rest periods may hinder recovery from the activity and fatigue may influence subsequent performance, whereas greater effect sizes may be obtained when the recovery period is longer compared to shorter (5-7 min, ES = 0.49; >8 min, ES = 0.44; 0.3-4 min, ES = 0.17) (Seitz and Haff, 2016). This may support the non-significant results from the Whelan, O'Regan and Harrison (2014) study where 90s rest were given between the resisted sprints (3 x 10 m). Participants in this study were active males and similar to the current study. However, it does not support the non-significant results from Mangine et al. (2018) or Thompson et al. (2021) who implemented rest periods between 4-9 min and 3 min, respectively. Although the Mangine et al. (2018) study only used a single resisted sprint at 5% of body mass which may not have had a potentiating effect. Conversely, Thompson et al. (2021) used a heavier load (~45% body mass) with 3 resisted sprints. Multiple sets have shown to produce greater effect sizes than single sets and may have implications for programming this type of training (Seitz and Haff, 2016). The two studies that used elite and high-level sprinters both implemented rest periods of 5 and 8 minutes (Matusiński et al., 2021, 2022). Whilst the specific strength levels of the athletes were not reported, the inclusion criteria stated that the elite female sprinters had been in the national team for a minimum of 2 years, had competed in the previous 12 months and had experience of resisted sprint training (Matusiński et al., 2021). Similarly, in another study involving elite sprinters, athletes had a minimum of 6 years training and competition experience and had just completed a 6-week training camp featuring sprint training and explosive strength work (Matusiński et al., 2022). The two studies using rugby athletes also showed contrasting training experience to the participants of the current study. The senior club players had over 2 years playing experience at a premier club and a minimum of 3 years resistance training experience (Cochrane and Monaghan, 2021). The experience of players in the Winwood et al. (2016) study was equally superior to the current study as they reported an extensive strength training history and experience of training with loaded sleds. By contrast, participants in this study were recreationally active with no competitive high-level participation or experience of resisted sprint training.

Individual variability in the present study supports the notion that PAPE depends on a number of factors. These may include the relative load of the sprint and its effect on velocity, the training status of the participants, and finally the balance between fatigue and potentiation of the conditioning activity.

PRACTICAL APPLICATIONS

The ability to maximise linear sprint ability is an important component in numerous sporting contexts. Post-activation performance enhancement has been shown in some instances to be highly individualised and may be dependent on several factors. This study showed that using 3 resisted sprints prior to a 15 m unresisted sprint, did not elicit a statistically significant PAPE for recreationally trained participants. However, when using SWC, some participants may have enhanced their acute sprint performance. Therefore, strength and conditioning coaches may consider alternative methods to acutely enhance sprint performance and consider individual responses to any preconditioning activity. Finally, the Run Rocket has been shown to be a reliable piece of equipment over short distances and further studies with differing protocols are recommended.

REFERENCES

1. Alcaraz, P.E. et al. (2018) 'The Effectiveness of Resisted Sled Training (RST) for Sprint Performance: A Systematic Review and Meta-analysis.', Sports Medicine, 48(9), pp. 2143–2165.
2. Beato, M., Drust, B. and Iacono, A.D. (2021) 'Implementing High-speed Running and Sprinting Training in Professional Soccer', International Journal of Sports Medicine, 42(04), pp. 295–299. Available at: https://doi.org/10.1055/a-1302-7968.
3. Blazevich, A.J. and Babault, N. (2019) 'Post-activation Potentiation Versus Post-activation Performance Enhancement in Humans: Historical Perspective, Underlying Mechanisms, and Current Issues', Frontiers in Physiology, 10, p. 1359. Available at: https://doi.org/10.3389/fphys.2019.01359.
4. Chomentowski III, P.J. et al. (2022) 'Running head: PAP and 40-yard sprint performance. The Effect Of Post-Activiation Potentiation On Subsequent 40-Yard Sprint Performance In High School Football Athletes In North Anerica.', International Journal of Sports Sciences & Fitness, 12(1), pp. 23–41.
5. Cochrane, D.J. and Monaghan, D. (2021) 'Using Sprint Velocity Decrement to Enhance Acute Sprint Performance.', Journal of Strength & Conditioning Research, 35(2), pp. 442–448.
6. Cross, M.R. et al. (2018) 'Training at maximal power in resisted sprinting: Optimal load determination methodology and pilot results in team sport ath-

letes', PLOS ONE. Edited by Ø. Sandbakk, 13(4), p. e0195477. Available at: https://doi.org/10.1371/journal.pone.0195477.
7. Cunningham, D. et al. (2013) 'Strength and power predictors of sprinting performance in professional rugby players', The Journal of sports medicine and physical fitness, 53, pp. 105–11.
8. Godwin, M. et al. (2020) 'Intra and intersession reliability of the Run RocketTM in recreationally trained participants', Journal of Human Sport and Exercise, 16(1). Available at: https://doi.org/10.14198/jhse.2021.161.05.
9. Harrison, A.J. and Bourke, G. (2009) 'The Effect of Resisted Sprint Training on Speed and Strength Performance in Male Rugby Players', Journal of Strength and Conditioning Research, 23(1), pp. 275–283. Available at: https://doi.org/10.1519/JSC.0b013e318196b81f.
10. Haugen, T.A. et al. (2014) 'The Role and Development of Sprinting Speed in Soccer', International Journal of Sports Physiology and Performance, 9(3), pp. 432–441. Available at: https://doi.org/10.1123/ijspp.2013-0121.
11. Kaplan, T., Erkmen, N. and Taskin, H. (2009) 'The Evaluation of the Running Speed and Agility Performance in Professional and Amateur Soccer Players', Journal of Strength and Conditioning Research, 23(3), pp. 774–778. Available at: https://doi.org/10.1519/JSC.0b013e3181a079ae.
12. Koo, T.K. and Li, M.Y. (2016) 'A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research', Journal of Chiropractic Medicine, 15(2), pp. 155–163. Available at: https://doi.org/10.1016/j.jcm.2016.02.012.
13. Lockie, R.G. et al. (2018) 'The Physical and Athletic Performance Characteristics of Division I Collegiate Female Soccer Players by Position', Journal of Strength and Conditioning Research, 32(2), pp. 334–343. Available at: https://doi.org/10.1519/JSC.0000000000001561.
14. Mangine, G.T. et al. (2018) 'A Resisted Sprint Improves Rate of Force Development During a 20-m Sprint in Athletes', Journal of Strength and Conditioning Research, 32(6), pp. 1531–1537. Available at: https://doi.org/10.1519/JSC.0000000000002030.
15. Matusiński, A. et al. (2021) 'The Effects of Resisted Post-Activation Sprint Performance Enhancement in Elite Female Sprinters', Frontiers in Physiology, 12, p. 651659. Available at: https://doi.org/10.3389/fphys.2021.651659.
16. Matusiński, A. et al. (2022) 'Acute effects of resisted and assisted locomotor activation on sprint performance', Biology of Sport, 39(4), pp. 1049–1054. Available at: https://doi.org/10.5114/biolsport.2022.108706.
17. Ortega-Becerra, M. et al. (2018) 'Determinant Factors of Physical Performance and Specific Throwing in Handball Players of Different Ages', Journal of Strength and Conditioning Research, 32(6), pp. 1778–1786. Available at: https://doi.org/10.1519/JSC.0000000000002050.
18. Petrakos, G., Egan, B. and Morin, J.-B. (2016) 'Resisted Sled Sprint Training to Improve Sprint Performance: A Systematic Review.', Sports Medicine, 46(3), pp. 381–400.
19. Prieske, O. et al. (2020) 'Time to Differentiate Postactivation "Potentiation" from "Performance Enhancement" in the Strength and Conditioning Community.', Sports Medicine, 50(9), pp. 1559–1565.
20. Sale, D.G. (2002) 'Postactivation potentiation: role in human performance. / Postactivation potentiation: role dans la performance humaine.', Exercise & Sport Sciences Reviews, 30(3), pp. 138–143.
21. Seitz, L.B. and Haff, G.G. (2016) 'Factors Modulating Post-Activation Potentiation of Jump, Sprint, Throw, and Upper-Body Ballistic Performances: A Systematic Review with Meta-Analysis', Sports Medicine, 46(2), pp. 231–240. Available at: https://doi.org/10.1007/s40279-015-0415-7.
22. Smith, C.E. et al. (2014) 'The effects of a postactivation potentiation warm-up on subsequent sprint performance.', Human Movement, 15(1), pp. 33–41.
23. Thompson, K.M.A. et al. (2021) 'Moderate Load Resisted Sprints Do Not Improve Subsequent Sprint Performance in Varsity-Level Sprinters', Journal of Strength and Conditioning Research, 35(1), pp. 72–77. Available at: https://doi.org/10.1519/JSC.0000000000002524.
24. Van Den Tillaar, R., Teixeira, A. and Marinho, D. (2018) 'Acute effect of resisted sprinting upon regular sprint performance', Acta Kinesiologiae Universitatis Tartuensis, 23, p. 19. Available at: https://doi.org/10.12697/akut.2017.23.02.
25. Whelan, N., O'Regan, C. and Harrison, A.J. (2014) 'Resisted Sprints Do Not Acutely Enhance Sprinting Performance', Journal of Strength and Conditioning Research, 28(7), pp. 1858–1866. Available at: https://doi.org/10.1519/JSC.0000000000000357.
26. Williams, J., Baghurst, T. and Cahill, M.J. (2021) 'Current perceptions of strength and conditioning coaches use of sled tow training.', International Journal of Sports Science & Coaching, 16(3), pp. 601–607.
27. Williams, J.J. et al. (2021) 'Postactivation Potentiation Effect of Heavy Sled Towing on Subsequent Sprints.', Journal of Strength & Conditioning Research, 35(5), pp. 1229–1233.
28. Winwood, P.W. et al. (2016) 'The Acute Potentiating Effects of Heavy Sled Pulls on Sprint Performance', Journal of Strength and Conditioning Research, 30(5), pp. 1248–1254. Available at: https://doi.org/10.1519/JSC.0000000000001227.
29. WONG, M.A. et al. (2017) 'Sled Towing Acutely Decreases Acceleration Sprint Time.', Journal of Strength & Conditioning Research, 31(11), pp. 3046–3051.
30. Zabaloy, S. et al. (2023) 'Narrative Review on the Use of Sled Training to Improve Sprint Performance in Team Sport Athletes', Strength & Conditioning Journal, 45(1), pp. 13–28. Available at: https://doi.org/10.1519/SSC.0000000000000730.
31. Zafeiridis, A. et al. (2005) 'The effects of resisted sled-pulling sprint training on acceleration and maximum speed performance.', Journal of Sports Medicine & Physical Fitness, 45(3), pp. 284–290.

32. Zisi, M. et al. (2022) 'The Acute Effects of Heavy Sled Towing on Acceleration Performance and Sprint Mechanical and Kinematic Characteristics.', Sports (2075-4663), 10(5), pp. 77–77.