Journal of Strength and Conditioning Research Publish Ahead of Print
DOI: 10.1519/JSC.0000000000002524

Moderate Load Resisted Sprints Do Not Improve Subsequent Sprint Performance in Varsity Level Sprinters

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This research was supported by a Mitacs Accelerate grant, in collaboration with the Speed River TFC. (IT08409)

Abstract

Resisted sprint training (RST) is commonly used for performance enhancement in athletics and team sports to develop acceleration ability. Evidence suggests that RST may be effective as a short-term intervention to improve successive sprints. While these improvements have been measured in team sport athletes, limited research has considered the acute effects of RST training in sprint-trained athletes. Therefore, the aim of the current study was to determine if performing RST with varsity level sprinters using sled-equivalent resistive loads of ~45% body mass results in a potentiation effect, leading to improvements in subsequent maximal sprint performance over 0-5 m and 0-20 m. Competitive sprinters (n=20), were randomly assigned to perform a pre/post maximal 20 m sprint separated by either 3 resisted (RST group) or un-resisted (URS group) sprints. The RST or URS protocol was performed on four occasions separated by at least 7 days. No significant differences were observed between the RST and URS groups comparing changes in sprint times over 0-5 m (URS Δ = <0.01 s ± 0.03 s, RST Δ = <0.01 s ± 0.03 s) and 0-20 m (URS Δ = 0.013 s ± 0.04 s, RST Δ = <0.01 s ± 0.04 s). We conclude that resisted sprints using sled equivalent loads of 45% body mass are ineffective at inducing a potentiating effect on subsequent sprint performance in varsity level sprinters. In this population of trained athletes, greater loads may be necessary to induce a potentiating effect.

Keywords: sled training, sled towing, potentiation, 1080 Sprint, horizontal power, acceleration

INTRODUCTION

The ability to accelerate is essential for athletic performance in both individual and team sports (3). Sprint acceleration is a result of both horizontal and vertical power production, which can be increased through changes in sprint mechanics (21) or by increasing lower limb muscle mass/strength (1,26). These modifiable characteristics are, therefore, targeted by coaches aiming to improve acceleration ability. Contrast training and resisted sprint training (RST) emphasize the use of these types of specific strengthening exercises, which can ultimately improve horizontal power production, leading to enhanced acceleration.

Contrast training involves a muscular overloading exercise, which precedes an outcome exercise such as sprinting, jumping, or throwing (23). Heavy back squats (>90% 1 repetition maximum (RM)) and depth jump exercises are most commonly employed as overloading stimuli and are believed to elicit a post-activation potentiation response (11,25). Post-activation potentiation is a physiological phenomenon believed to cause myosin regulatory light chains to become phosphorylated, leading to an increased sensitivity of actin and myosin to calcium, which theoretically allows for greater strength and speed performance (11,25). Whether it be related to the effects of post-activation potentiation, or another performance-enhancing mechanism, improved sprint performances have been reported following overload exercises (16). Resisted sprint-training (i.e. sprinting while pulling a weighted sled) can be considered an acceleration specific contrast training protocol because it offers the ability to overload muscles in similar positions required during an unloaded acceleration, without significantly altering sprint mechanics (22). This specificity is vital to improving outcome exercise performance (unloaded sprinting), as performing a conditioning exercise that uses similar joint angles to the outcome exercise results in the greatest transfer effect (7,11,20). Resisted sprint training studies lasting 4 – 8 weeks (2,15,17,18,27) have reported changes in stride length, stride frequency and ground contact time, while acute responses to resisted sprints such as increases in horizontal force production have been demonstrated (14).

Few studies have examined the potentiating effect of resisted sprints in highly-trained subjects, and of those that exist, protocol variations such as: running surface, harness attachment site, temporal pattern of data collection within athletes' training season, measurement error, and subject characteristics contribute to inconsistent outcomes within and between studies. Two recent investigations using trained rugby athletes have shown improvements in sprint performance after very heavy resisted sprints (24,30). Improved sprint performance in these studies contrasts with an earlier study by Whelan *et al*. (28), who found no enhancement in sprint performance following moderate load resisted sprints (25-30% body mass) in physically active, but non-specifically trained men. Comparing these studies, the difference in outcome may be attributed to the resisted sprint load or subject variability due to the subject's training status. In the study by Whelan *et al*., which used lighter loads (26), the inter-trial and inter-individual variability of the participants may have masked performance benefits. That is, a true effect of moderate-load sprinting (if it occurred) may have been undetectable, owing to the large variability about the mean changes. This is particularly likely in un-trained runners who would have a relatively high variability that may overshadow small, but potentially meaningful changes in sprint performance. Alternatively, the heavy resisted sprint loads used by Seitz *et al.* (24) and Winwood *et al.* (30) of 75% body mass may be necessary to induce changes in sprint performance. Although, it is unclear if this load is universally required to elicit a potentiation response in all subjects, or if it is only appropriate for rugby union athletes, who train for the specific demands of a strength-dominant sport. If the resisted sprint load necessary to induce a potentiation effect is dependent on the subjects' training focus, it is possible that lighter loads may be suitable in populations that focus more on speed of movement, such as sprinters. Additionally, recent work by Jarvis *et al.* (13) has shown that a lighter load of ~50% body mass was effective at improving subsequent sprint performance in varsity level team sport athletes.

Therefore, with a group of highly trained sprinters, it was hypothesized that inter-sprint variability would be extremely low, allowing any observed changes in performance to be attributed to the resisted sprint intervention. A small, but meaningful, change in sprint performance was expected following the moderate load (~45% body mass sled equivalent load) resisted sprint intervention, as recent work has shown improvements in sprint performance following similar loads.

METHODS

Experimental Approach to the Problem

A randomized control experimental design with an un-resisted sprint control group (URS, n=10) and intervention group (RST, n=10) was used to determine the post-exposure effects of resisted sprint-training on subsequent 0-5 m and 0-20 m sprint performance. Inter-sprint variance of the subjects was initially determined, to ensure changes in performance could be confidently attributed to the intervention. Testing of both the URS and RST subjects was conducted during the subjects' competitive season to ensure high-level performances during all trials. Subjects were randomly assigned to either the URS or RST group for four testing sessions. In order to evaluate the effectiveness of a moderate resistive load (~45% body mass sled equivalent load) the resistive loading parameters of the 1080 Sprint device used in the current study were mathematically matched based on previous work (19). The mathematical matching of the 1080 Sprint resisted load to a sled equivalent load was necessary, as the 1080 Sprint resistance is not dependent on sprint surface coefficient of friction, is unidirectional (horizontal) and remains constant during the entire sprint duration.

Subjects

Twenty track and field sprinters (male=11, female=9) who had previous experience with resistance training, sprint-training, and resisted sprint-training using traditional weighted sleds were recruited for the study (age = 20 ± 2 years, female body mass = 59 ± 6 kg, male body mass

= 76.1 ± 7.8 kg) (Table 1). Subjects were excluded if their primary indoor track event was ≥300 m. In addition to the acceleration training days during which data was collected, subjects completed 2-3 resistance training sessions, one maximal velocity sprint session, and one work capacity sprint session per week. This additional training was consistent among all subjects. The protocol was approved by the research ethics committee at the sponsoring university, and written informed consent was obtained from all subjects prior to testing.

[INSERT TABLE 1. HERE]

Procedures

1080 Sprint Resistance and Data Collection Tool

All data was recorded using a 1080 Sprint device (1080Motion, Sweden), which uses a robotic flywheel resistance and simultaneously records velocity, power, horizontal force, distances and time. The error of the 1080 Sprint has previously been examined and is low across all measurements (velocity error = ± 0.5%, distance error = ± 5 mm, force error = ± 4.8 N) (4). Subjects attached a harness to their waist from which a tether cord was run to the 1080 Sprint device. Baseline and final sprints were measured using the “isotonic” function of the 1080 Sprint with the minimum functional load of 1 kg, which is required to maintain tension on the cord. Given that a minimal resistive load is required for the device to function and this is the first study to simultaneously use the 1080 Sprint as a training and data collection tool, we performed fifty sprint trials while measuring 0-10 m, 10-20 m and 20-30 m splits concurrently with a Freelap timing system (Freelap, California, USA), a Stalker Pro II Radar system (Applied Concepts, Texas, USA) and the 1080 Sprint (1080Motion, Sweden) to determine the similarity between each timing device. This comparison was performed to allow for sprint times obtained using timing gates or radar timing systems to be compared to the sprint times obtained in the current study.

Determining Population Variability

Thirty unloaded sprint trials were used to determine typical inter-sprint variability within a varsity level sprint-trained subject. Subjects performed 3 maximal 20 m sprints from sprint blocks, in track spikes, on an indoor polytan track surface, with outcomes measured using the 1080 Sprint device. Data was stored online for later analysis. This protocol was performed on two separate days to determine individual within and between day inter-sprint variation.

Testing Protocol

Subjects performed five maximal 20 m sprints. The first was used as the baseline sprint, following which, subjects in the RST group performed three resisted sprints (Sprint 2 - Sprint 4), while subjects in the URS group performed three un-resisted sprints. Sprint 5 was the final sprint and was un-resisted for both groups. A minimum of 3 min was given between each sprint to ensure full recovery while not exceeding the 10 min time span in which an acute performance enhancing effect is likely to be observed following a potentiating stimulus (29). Subjects performed either the RST or URS protocol on four separate occasions to account for daily fluctuations in performance.

Statistical Analysis

Pearson correlations and the coefficient of variation (CV) was used to compare and characterize the difference between the 1080 Sprint, Freelap and Stalker Pro II Radar timing systems. A factorial 2(Group) x 2(Test) x 4(Day) repeated measures ANOVA was used to compare baseline and final sprint times for the RST and URS groups. A *t*-test was used to compare both the changes in step rates and changes in average horizontal force production. An *alpha* level of $p<0.05$ was selected, *a priori*. As previously stated, a magnitude-based inferences approach was concurrently used to account for changes in performance which may have been missed using null-hypothesis testing. The CV of the testing population was determined using a sub-group of sprinters as described above, and the smallest worthwhile change (SWC) in performance was determined for 5 m and 20 m sprints using 0.2 of the group standard deviation (12). Results are presented as mean ± SD.

RESULTS

Sprint times obtained using the 1080 Sprint, Freelap and Stalker Pro II Radar timing systems were practically identical (Table 2). No significant changes in sprint times over 0-5 m (Δ URS = -0.003 s ± 0.03 s, RST Δ = 0.0008 s ± 0.03 s, p=0.63) or 0-20 m (URS Δ = -0.01 s ± 0.04 s, RST Δ = -0.003 s ± 0.04 s, p=0.33) were observed in either the RST or URS groups (Figure 1). No changes in step rate (0-5 m p=0.32, 0-20 m p=0.20) or average horizontal force production (0-5 m p=0.28, 0-20 m p=0.56) were observed over 0-5 or 0-20 m following the RST intervention. Average individual CV was 1.82% (~0.02 s) at 0-5 m and 1.19% (~0.04 s) over 0-20 m. The

SWC in performance for 0-5 m was 0.01 s and it was 0.03 s over 0-20 m. The mean group change in performance did not exceed the SWC after performing the RST intervention over 0-5 m or 0-20 m. Therefore, RST using moderate loads did not improve post-exposure sprint performance in highly trained sprinters after being analyzed using a null-hypothesis or magnitude-based inferences statistical approach.

[INSERT TABLE 2. HERE]

[INSERT FIGURE 1. HERE]

DISCUSSION

We sought to examine whether resisted sprints using a moderate load could induce a performance enhancing effect in sprint-trained subjects over 0-5 m and 0-20 m. The methods were designed such that inclusion criteria selected for highly trained sprinters to minimize between-sprint variation and all testing was performed during the subjects' competitive season to ensure maximal effort during all trials. Trials were completed at an indoor training facility on a high quality polytan track surface, limiting extraneous and variable environmental factors. Additionally, a 1080 Sprint device was employed for resistive loading and sprint characteristic measurement, which improves future replicability and ensures all resistive loads remained constant. Since the 1080 Sprint is controlled electronically using a robotic flywheel system, the resistance applied during the sprint is highly reliable and quantifiable; as opposed to weighted sleds wherein the resistive load can change substantially depending on the coefficient of friction, which varies with the track surface, sled runner quality, and sled velocity (19). Finally, in addition to the study criteria meant to reduce these limitations, a parallel magnitude-based statistical approach was included as a form of analysis. The use of this approach has become increasing popular in the field of sport performance research, as it is not biased by statistical power and allows for subjects within a population to be assessed individually against both their own previous performances and a predetermined "meaningful" change (5). A strong argument for the use of this analysis when examining highly trained subjects who may expect to see relatively small changes as a result of an intervention has been made previously (5,10,12).

A major strength of the current study was the highly-trained nature of the participants. With an average individual CV over 5 m and 20 m sprints of less than 2%, subjects repeatedly achieving sprint times within 0.04 s. Thus, even if a small effect occurred, it would have been detected. This consistency is similar to the variation (~2%) seen in professional athletes used in other training studies (8) and is an essential quality often neglected in the field of sprint research which allows outcomes to be confidently attributed to the intervention under examination. No performance enhancing effect was observed following the RST intervention over 0-5 m or 0-20 m. Step rate and horizontal force production were further analyzed to characterize sprint characteristics. As expected, based on the lack of change in sprint times, no changes in either step rate or force production was observed. This outcome is consistent with the results of Whelan *et al*. (28) who showed no acute enhancement of sprint velocity after performing resisted sprints in physically active men using a slightly lighter load of 25-30% body mass. Therefore, even when ensuring consistent loading parameters, using subjects with low inter-sprint variability and analyzing data with a statistical approach specifically designed to evaluate changes in this type of scenario, we do not observe changes in sprint performance following moderate load resisted sprints (~45% body mass sled equivalent load).

The lack of change in sprint performance following the current intervention may suggest that a greater resistive load is necessary to induce an acute potentiation effect. Although the resisted sprint literature has historically refrained from using resistive loads greater than ~40% body mass due to the belief that heavy loads may negatively impact sprint mechanics, two recent studies have assessed the performance enhancing ability of resistive sprint with loads as high as 150% body mass (24,30). Both studies reported improvements in sprint times over 15-20 m after performing weighted sled sprints with ~75% body mass loads but decrements in sprint performance when using loads of 125% and 150% body mass (24,30). Both groups also used trained rugby athletes as their subjects, making it plausible that the 75% body mass loads were optimal for this population due to the strength-oriented nature of their training. A previous investigation of post activation potentiation suggests that stronger individuals (1 RM squat >160 kg) have a greater improvement in vertical jump performance (+4.01%) compared with those who had a 1RM squat of < 160 kg (+0.42%) following a potentiating protocol (9). This suggests that subjects must have a specific baseline strength to benefit from a potentiating protocol, and was a rationale for our hypothesis that lighter loads may yet be effective for sprinters, who possess explosive power, but are not typically defined as strength-based athletes per se.

While strength status may play a contributing role in potentiation ability, new research focusing on determining optimal loading parameters for maximal horizontal power may provide an alternative perspective. Using both recreational and elite level sprinters, Cross *et al*. (6) very recently demonstrated that both populations produced maximal horizontal power at resistive loads of ~80% body mass. If these loads consistently allow subjects of various athletic backgrounds to achieve maximal horizontal power, perhaps the potentiating effect seen by Winwood (30) and Seitz *et al*. (24) was a result of their subjects performing sprints in this optimal zone, rather than their strength status. This would indicate that performing resisted sprint training as a potentiation technique requires athletes to use loads of ~80% body mass, or more specifically, loads which allow the individual to produce maximal horizontal power. To accommodate both potential explanations of how resistive sprint loads of ~80% body mass improve sprint performance, future research should incorporate strength testing into their design to categorize subjects based on strength levels while additionally monitoring whether subjects are producing their maximal horizontal power.

Sled equivalent resisted sprint loads of ~45% body mass using a 1080 Sprint do not elicit an immediate performance enhancing effect in varsity level sprinters. Athletes with highly reproducible results, such as the sprint-trained athletes used in the current investigation, offer the greatest chance of observing small, but meaningful, alterations in performance and are recommended for future investigations in this area. Future research should also determine whether performing resisted sprints with a load that allows subjects to achieve maximal horizontal power is the determining factor when desiring a performance enhancing effect.

PRACTICAL APPLICATIONS

Sprint-trained athletes are capable of highly reproducible results, and are thus optimally suited for examining potentially small changes in sprint performance. The results did not support the hypothesis, that a potentiation effect would be observed following resisted sprints with moderate loads. Therefore, it is not recommended that coaches use these loading parameters (45% body mass sled load) as an acute performance enhancing method. Findings from Jarvis *et al.* (13) currently suggest that a minimal load of 50% body mass should be considered if trying to structure resisted sprints within the warm-up to acutely enhance sprint performance during competition. We also showed that the 1080 Sprint device can be used as a reliable timing system while simultaneously being used as a training tool. The 1080 Sprint is therefore, a viable research and training tool for researchers and coaches to accurately control resisted sprint training loads while measuring other commonly evaluated sprint characteristics such as sprint time, horizontal force production, step rates, sprint velocity and horizontal power.

ACKNOWLEDGEMENTS

The authors thank the athletes who participated in the study and the coaches for their time. This study was supported by a Mitacs Accelerate grant, in collaboration with the Speed River TFC (IT08409). The authors declare no conflict of interest.

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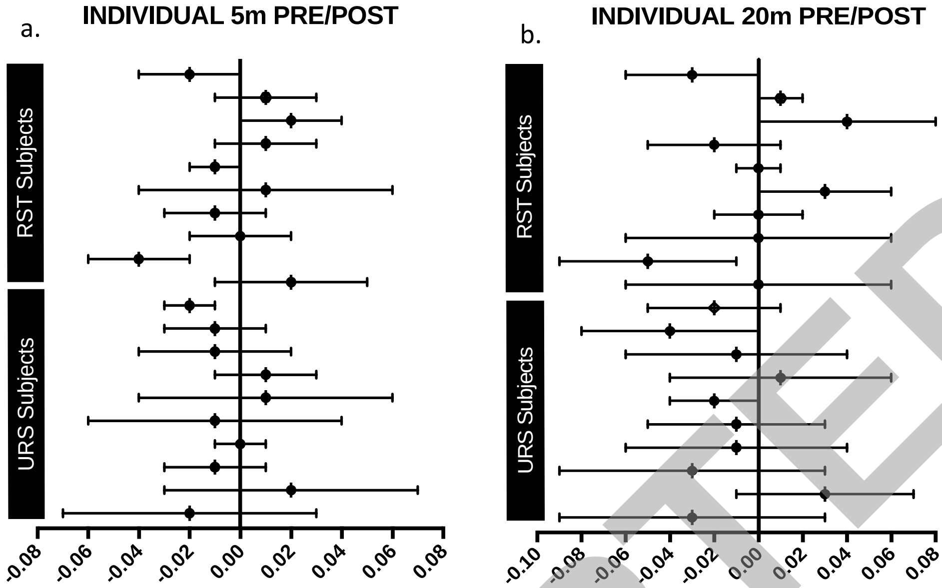
Table 1. Subject Characteristics within the Resisted Sprint Training and Un-Resisted Sprint groups.

Subject Characteristics	RST	URS
Age (y)	20.6 ± 2.3	19.7 ± 1.6
Number of Subjects M/F	6 / 5	5 / 4
Mass M/F (kg)	75.4 ± 8.7 / 61.2 ±4.4	75.4 ± 8.7 / 58.8 ± 7.3
Best time over 60m M/F (s)	6.75 - 7.24 / 7.59 - 7.77	6.87 - 7.19 / 7.62 - 8.04

Table 2. Comparative sprint analysis between 1080 Sprint, Freelap timing gate system and Radar system.

		0-10m	10-20m	20-30m
Freelap - 1080 Sprint	*Pearson Correlation*	0.87	0.99	0.98
	Coefficient of Variation %/s	4.75 (0.002s)	2.03 (0.003s)	2.19 (0.007s)
Radar - 1080 Sprint	*Pearson Correlation*	0.87	0.94	0.99
	Coefficient of Variation %/s	5.11 (0.015s)	4.32 (0.008s)	1.51 (0.002s)

Figure 1. Changes in Sprint Time Over 0-5m and 0-20m



Individual differences between baseline (Sprint 1) and final (Sprint 5) sprint times over 5 m (a.) and 20 m (b.). Individual points represent an average change in sprint time for subjects over the four trials with error bars representing individual SD. A meaningful change in performance was determined to be 0.01 s over 0-5 m and 0.03 s over 0-20 m.