BRIEF REVIEW

Sprinting Performance and Resistance-Based Training Interventions: A Systematic Review

Richard Bolger,[1,2] Mark Lyons,[1] Andrew J. Harrison,[1] and Ian C. Kenny[1]

[1]Department of Physical Education and Sport Sciences, Biomechanics Research Unit, University of Limerick, Limerick, Ireland; and [2]Department of Health Sport & Exercise Science, Waterford Institute of Technology, Waterford, Ireland

Abstract

Bolger, R, Lyons, M, Harrison, AJ, and Kenny, IC. Sprinting performance and resistance-based training interventions: A systematic review. *J Strength Cond Res* 29(4): 1146–1156, 2015—The purpose of this systematic review was to search the scientific literature for original research, addressing the effects different forms of resistance-based training have on sprinting performance in competitive sprinters. Specific key words (Sprinters OR Sprint) NOT (Rugby, Soccer, Cycling, Swimming, Paralympic, and Nutrition) were used to search relevant databases through November 2013 for related literature. Original research was reviewed using the Physiotherapy Evidence Database scale. Five studies met the inclusion criteria: actively competitive adult male sprinters who participated in a resistance-based intervention (>4 weeks), with outcome measures in the form of 10- to 100-m sprint times. Exclusion criteria included acute studies (<4 weeks), nonsprinting populations, and studies with no performance outcome measures (10- to 100-m sprint times). Three of the 5 studies used both locomotor resistance and fixed plane resistance, whereas the remaining 2 studies used more fixed plane resistance, for example, squat and leg extension. Three of the studies showed a statistical improvement in sprinting performance measures, for example, a decrease in 30-m sprint time ($p = 0.044$), whereas 1 study showed a decrease in sprinting performance. The analysis concluded that resistance-based training has a positive effect on sprinting performance. Varied input of locomotor resistance and fixed plane resistance has resulted in similar percentage change for sprinting performance. This review adds to the body of knowledge by strongly highlighting the dearth of literature exploring the effects of resistance-based training on sprinting performance in competitive sprinters. The short duration and wide range of exercises implemented in studies to date are of concern, but coaches should not hesitate to implement well-planned resistance programs for their sprint athletes.

Key Words sprinters, resistance training, plyometrics, specificity, transference

Introduction

Sprinting performance has captivated audiences across the world since the ancient Olympic games in the eighth Century BC. Numerous studies have been conducted using sprinters as a population. The majority of these are acute studies and investigate a wide variety of topics such as physiological changes (14,15,29), alteration in stride length and frequency (1,7,16,19), and acute biomechanical changes (10,32,39,42,43,53). There are concerns that resistance training will result in muscle hypertrophy, increasing athlete mass thus impacting on speed (47,62). Ross and Leveritt (47) have shown an increase (5–10%) in type I and type II fiber cross-sectional area, in sprinters after prolonged training ranging from 8 weeks to 8 months, which accounts for top-level sprinters' muscular physiques. Ross and Leveritt also note that as a physique becomes more muscular, as in the case of a bodybuilder, contractile characteristics (concentric/eccentric) become slower. For clarity, this article refers to exercises, which involve bounding, sled towing, prowler pushing, or any other form of resisted sprint training as locomotor resistance. Exercises such as back squats, squat jumps, leg extensions, or exercises, which are performed on the spot, or in a fixed plane, are referred to as fixed plane resistance.

To date, a large number of studies have examined the effects of resistance-based interventions on sprinting performance in team sports athletes, with the greatest volume of research conducted on American football, Rugby, and soccer teams. American football studies have focused on various training methods over a season, yet report inconsistent findings about which method can best improve speed development (22,31). Many of the studies have demonstrated improvements in running performance outcome measures after a season of resistance training (13,22,23,55,60). However, various methods have been used to elicit improved speed development of these athletes. Many have used fixed plane resistances such as jump squats (21), power cleans (13,20–23,34,48,60), medicine ball

Address correspondence to Richard Bolger, richard.bolger@ul.ie.

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throws (38), and Olympic weightlifting variations (13,20–23,48,60) supplementing their programs with more locomotor-oriented resistance training such as plyometrics (13,20,34,38,55) and maximal treadmill running (48).

The available studies on Rugby and sprinting performance suggest similar findings as American football. For example, Baker's (3) study report a shorter intervention time of 6–8 weeks, unlike the American football studies that lasted as long as an entire season. These studies have used similar training methods to American football, including many locomotor resistance exercises such as over-speed training (9), resisted sprint training (18,59), plyometric training (34,54), and fixed plane resistance exercises such as jump squats (3,9,17,44) and Olympic weightlifting variations (3).

The body of research on soccer has also presented similar findings with interventions lasting from 3 to 10 weeks (8,12,27,28,35,36,41,46,56–58,61) involving fixed plane resistance training interventions of back squats (27,35,36), half squats (35,41,46,61), and countermovement jumps (35,46,56). They also use many locomotor training exercises, including repeated sprint training (12,28,57,61), plyometrics (8,35,36,41,46,56), speed, agility, quickness (27), and assisted and resisted sprint training (58). Many of these studies have used both locomotor and fixed plane resistance programs concurrently, some even using complex training methods (36).

Several key recommendations have arisen from these studies, primarily a necessity for further research examining the validity, transfer, and periodization method of these programs. The overall theme suggests that longer (>8 weeks) studies yield improved speed development (8,12,13,20–23,27,31,35,51,54,55,57,59–61), and that a combined approach of resistance training, and locomotor training improves speed (3,11,13,22,27,31,48,54,55,58,61,62). Both American football and rugby have position-specific considerations, which may influence overall study results (2,13,25,31,44). The soccer studies showed significant improvements with interventions lasting longer than 8 weeks, again with a combined approach of resistance training and locomotor training (8,12,27,57,58,61). There was little focus on running technique development in these studies, and none of the studies tested speed beyond 60 m.

From a broader perspective, the performance outcome measures of the studies are not easily comparable with competitive sprint performance, as it is harder to control subject variability in running mechanics and body mass. This is partly due to an overall difference in focus on body composition, as sprinting strength to weight ratio is important for the expression of force. A greater body mass to strength ratio will aid overall speed production (47), whereas both American football (25,45) and rugby (2) place greater emphasis on heavier body mass in conjunction with strength, speed, and power due to the collision-based nature of their sports. The absence of resistance training trials within the sprinting population is apparent, yet most are performing resistance training as part of their overall training program. Longitudinal controlled trials involving track athletes, in particular sprinters, are not abundant in the literature (62). This illustrates a gap in the literature on resistance modality and programming for competitive sprinters.

Numerous review articles have aimed to clarify the effects of different modalities of training on sprinting performance (6,11,24,26,49). The representation of sprinters among their population samples, however, is sparse. To date, strength and conditioning professionals and athletics coaches only have a small number of sport-specific studies to draw from to validate their training program selection for the modern sprinter. This systematic review focuses specifically on the prevalence and effects of various resistance training modalities on sprinters' performance. There is a lack of evidence-based research to support the apparent beneficial effects of various resistance training modalities on performance in competitive sprinters. A key consideration, however, is whether resistance training improves sprinting performance specifically. If so, what type of resistance training modalities or exercises are best suited for increased sprint performance? The purpose of this systematic review was to search the body of scientific literature for original research, addressing the effects of different forms of resistance training on sprinting performance in competitive sprinters.

METHODS

Experimental Approach to the Problem

The Cochrane Collaboration Prisma protocol (33) was used to complete the review. Electronic databases from 1946 to November 2013 were searched, including Pub Med, CINAHL, Science Direct, MEDLINE, Sports Discus, *Journal of Strength and Conditioning Research*, and the *Strength and Conditioning Journal*. Key words used were Sprinters OR Sprint NOT Rugby, Soccer, Cycling, Swimming, Paralympic, and Nutrition. Search terms were modified accordingly to fit the requirements or nuances of the database used.

Study Criteria

Studies were eligible if they met the following inclusion criteria: competitive adult male sprinters who participated in a resistance-based intervention (>4 weeks), with outcome measures of sprinting performance (10- to 100-m sprint times). Sprinters were defined as those who are currently competitive in 100- to 400-m event distances. Interventions included any resistance training, including plyometrics, weight training, calisthenics, and resisted running, but not excluding any other novel approaches where resistance is applied to the body. Studies were excluded if they were acute in nature postactivation potentiation studies or biomechanical studies without a training intervention. Studies involving untrained subjects, team sport athletes, or nonsprinters were also excluded. Subjects needed to be 16- to 35-year-old healthy adults with no musculoskeletal injuries.

Quality Assessment

Original research was reviewed using the Physiotherapy Evidence Database (PEDro) scale (33). The PEDro scale consists of 11 items related to scientific rigor, including eligibility criteria, random allocation strategy, concealed allocation, follow-up comparison, baseline comparison, blinding of subjects, therapists (i.e., trainers) and assessors, intention to treat, between-group analysis, and both point and variability measures. Five studies met the inclusion criteria (4,5,30,31,50), a similar number of studies used in a investigation by Yamamoto et al. (62) on elite endurance runners, which were then independently evaluated by 2 reviewers using the PEDro scale. Consensus was achieved on scores given to the 5 articles. A third reviewer was not needed in this case to resolve scoring issues. The Kappa value (measure of observed agreement) for all 5 articles was 1.0 (perfect agreement).

Data Extraction

Data were extracted using a standardized form created in Visual Basic to filter the required information into a continuous string in Microsoft Excel. The form included a hierarchy for assessment including the study citation and the inclusion/exclusion criteria. Studies were assessed first by journal title, second by abstract, and third by full article review, when the journal article was either included or excluded based on the criteria illustrated in Figure 1.

Results

Physiotherapy Evidence Database scores for the 5 selected articles ranged from 6 to 7 out of a maximum of 11 (Table 1). Concealment of allocation is not entirely relevant in studies of this nature because, given the nature of resistance training and sample selection methods used, it is difficult for

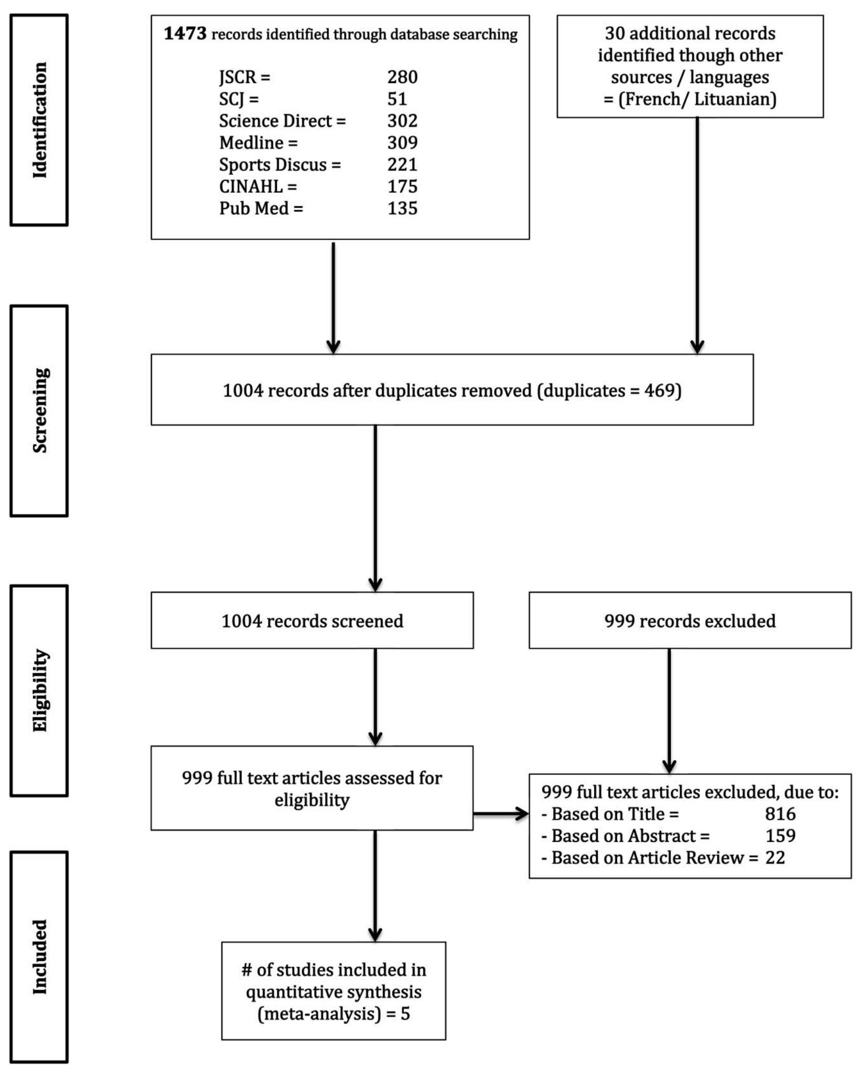

Figure 1. Criteria for selection of articles for review.

Table 1. Physiotherapy evidence database scale (40).

	Kamandulis et al. (30)	Balsalobre-Fernandez et al. (4)	Martinopoulou et al. (37)	Blazevich and Jenkins (5)	Satkunskienė et al. (50)
Eligibility criteria were specified	1	1	1	1	1
Subjects were randomly allocated to groups	0	0	1	1	0
Allocation was concealed	0	0	0	0	0
The groups were similar at baseline regarding the most important prognostic indicators	1	1	1	1	1
There was blinding of all subjects	0	0	0	0	0
There was blinding of all therapists who administered the therapy	0	0	0	0	0
There was blinding of all assessors who measured at least 1 key outcome	0	0	0	0	0
Measures of at least 1 key outcome were obtained from more than 85% of the subjects initially allocated to groups	1	1	1	1	1
All subjects for whom outcome measures were available received the treatment or control condition as allocated, or, where this was not the case, data for at least 1 key outcome were analyzed by "intention to treat"	1	1	1	1	1
The result of between-group statistical comparisons is reported for at least 1 key outcome	1	1	1	1	1
The study provided both point measures and measures of variability for at least 1 key outcome	1	1	1	1	1
Total points awarded	6	6	7	7	6

researchers to keep themselves and participants unaware of the treatment and groups involved in these types of studies. Blinding of subjects and therapists (i.e., trainers) was also not applicable in this case.

Three of the 5 studies reported increased running performance after training intervention. These studies reported that the increase was statistically significant. A fourth, Blazevich and Jenkins (5), reported that the increase was not statistically significant. The fifth, Satkunskienė et al. (50), showed a decrease in running performance after intervention. Three of the 5 studies (30,37,50) used locomotor-oriented resistance training involving unilateral exercises, from plyometrics to parachute resisted running, whereas the remaining 2 studies (4,5) used more traditional bilateral movements or fixed plane resistance such as leg extensions and squats. Notably, all groups used exercises of a dynamic or explosive nature with the exception of the Blazevich and Jenkins' (5) study. All 5 studies are summarized in Tables 2 and 3.

The study by Kamandulis et al. (30) scored 6/11 on the PEDro scale. Random allocation was not used, and blinding of subjects and therapists (i.e., trainers) was not possible in this case. Kamandulis et al. (30) examined contractile properties of the quadriceps as well as running performance after 3 weeks of power endurance training. The training intervention consisted of maximal-intensity sprint repetitions with short recovery periods, followed by 1-week recovery

Table 2. Reviewed articles.*

Authors	Subject description (n)	Anthropometrics	Resistance training type and duration	Description of treatment and control groups	Results (sprinting outcome measure)	Sprint performance (%)	Physiotherapy evidence database scale
Kamandulis et al. (30)	7 national and international sprinters: 100 m = 10.81 s (*SD* = 0.22); training experience = 6.0 y; *SD* = 1.0	*M* age = 20.7 y, *SD* = 1.8; *M* height = 1.82 m, *SD* = 0.006; *M* mass = 73.0 kg, *SD* = 11.0; *M* fat % = 7.6%, *SD* = 2.9	Power endurance, 3 wk; recovery, 1 wk; PT, 4 wk; total = 8 wk (27 sessions)	PE = 60–90% of max for 20 s 5–10 times (0.5- to 1-min rest) (hurdles, upstairs, uphill, on spot); PT = 95–100% of max for 5–10 s 5–10 times (5-min rest); CT = NA	*SD* = 0.96; $p \leq 0.05$, ES = 1.7; MVC: ^7.4% (*SD* = 7.3%); CMJ: ^3.5% (*SD* = 8.0%); DJ: ^8.7% (*SD* = 7.9%) ($p \leq 0.05$ in all cases, ES = 1.4–1.7)	60 m ^1.83%	6
Balsalobre-Fernandez et al. (4)	7 Spanish high-level hurdlers personal record = 54.78 ± 2.54 s; training experience = national and international competitors	*M* age = 21.7 ± 2.4 y; *M* height = 181.8 ± 3.9 cm; *M* mass = 75.1 ± 4.1 kg	Maximal PT, 10 wk; 2 times per wk; total = 10 wk	PT = 40% of 1RM + increments of 5% until max power was attained (Myotest Pro); squat jumps; CT = NA	Improved 30 m ^1.43%, *SD* = 4.13 ± 0.16, $p = 0.044$*; 7.9% increase in 1RM (kg) ($Z = -2.03$, $p = 0.021$, power = 0.70, $\delta c = 0.39$); 2.3% increase in squat jump ($Z = -1.69$, $p = 0.045$, power = 0.31, $\delta c = 0.29$); 1.43% decrease in 30-m sprint ($Z = -1.70$, $p = 0.044$, power = 0.46, $\delta c = 0.12$); 4% increase in power (W) ($Z = -0.98$, $p = 0.16$, power = 0.05, $\delta c = 0.28$)	30 m ^1.43%	6
Martinopoulou et al. (37)	16 sprinters training experience = 4 ± 1.1 y of sprint training; 8 parachute; 8 control	*M* age = 25 ± 4 y; *M* height = 172 ± 0.8; *M* mass = 61.5 ± 10.2	Resisted sprint training; parachute; 3 times per wk; total = 4 wk	PT ≥10% decrease in running velocity (parachute); maximum sprints of 0–50 m; CT = maximum sprints of 10–50 m; unresisted training (no parachute)	PT improved 10, 20, 40, and 50-m; sprints; resisted $p = 0.001$; unresisted $p = 0.04$	Not disclosed	7

Blazevich and Jenkins (5)	10 Nationally ranked sprinters; 100- to 400-m events; training experience ≥5 y	*M* age = 19.0 ± 1.4 y; *M* height = 1.82 ± 0.05 cm; *M* mass = 75.7 ± 4.7 kg	Standardization training = 4 wk; RT high velocity = 7 wk; RT low velocity = 7 wk; total = 14 wk	ST = 3 sets 10RM slow; HV = 30–50% of 1RM; SV = 70–90% of 1RM; 4-min recovery; CT = NA	High-velocity group; improved flying 20 m = $p < 0.20$	HVG 20 m; fly = ^1.9%	7
Satkunskienė et al. (50)	7 sprinters training experience = elite 60 m; result 6.77–7.51 s	*M* age = 26 ± 2.5 y; *M* height = 183.0 ± 4.11 cm; *M* mass = 76.0 ± 3.27 kg	Power endurance = 4 wk; PT = 4 wk; 3 times per wk 8 wk; total = 8 wk	Power endurance = 60–90%; 30–60 s passive rest; PT = 100%; 3- to 5-min passive rest; CT = NA	Running speed 30- to 40-m time = pre 9.62 ± 0.35 s; post 10.0 ± 0.57 s	30–40 m = −0.38%	6

*PE = power endurance; ES = effect size; PT = power training; CT = control trial; MVC = maximum voluntary contraction; CMJ = countermovement jump; DJ = drop jump; 1RM = 1 repetition maximum; RT = resistance training; HV = high velocity; HVG = high-velocity group; NA = not applicable; ST = standardization training; SV = slow velocity.

and 4 weeks of high-intensity power training. The high-intensity power training involved running with weight attached through a belt, jumps from 1 step followed by a vertical jump, forward jumps, and crouch-start running. Athletes used intensities of 95–100% of maximum for 5–10 seconds, repeated 5–10 times, with 5-minute recovery between exercises. The power endurance training involved vertical jumps, multiple forward jumps, running exercises (hurdles, upstairs, uphill, and on the spot), and sprints alternating with slow jogging. The athletes performed each exercise at 60–90% of maximum for 20 seconds, which they repeated 5–10 times with 30-second rest intervals between exercises. This combination of power endurance training followed by high-intensity power training resulted in improved 60-m sprint times by 1.83% ($SD = 0.96$; $p \leq 0.05$, effect size [ES] = 1.7). The authors suggested that sprint performance is poorly predicted by muscle intrinsic properties, and that neural adaptation provides for the improved adaptation.

Balsalobre-Fernandez et al. (4) recorded a score of 6/11 on the PEDro scale due to the small sample size ($n = 7$), the absence of a control group, and blinding within the study. Balsalobre-Fernandez et al. (4) evaluated the effect of maximal power training on performance in sprinters over a 10-week intervention. They used squat jumps as the primary exercise, starting at 40% of squat jump, 1 repetition maximum (1RM) with subsequent increments of 5% until maximum power output was attained (measured using a Myotest Pro; Myotest Inc., Durango, CO, USA). This was performed twice a week for a 10-week period. Their study suggests that neural adaptation is again the primary mechanism underlying performance gain, although this was not quantified or measured. Balsalobre-Fernandez et al. (4) observed improvements in squat jump 1RM of 7.9% with a mean difference pre-post of 13.7 kg ($p = 0.021$), a 2.3% increase in flight time for the squat jump with a mean pre-post difference of 13.9 milliseconds ($p = 0.045$), and a 1.43% improvement in 30-m sprint time with a mean pre-post difference of −0.06 seconds ($p = 0.044$).

Martinopoulou et al. (37) scored highest with 7/11 on the PEDro scale as a result of using random allocation of groups. Martinopoulou et al. (37) studied the effects of resisted sprint training on sprint performance in competitive sprinters ($n = 16$). The study was conducted during the precompetitive phase, lasting 4 weeks. The subjects were divided into a resisted training group (using the parachute), and an unresisted group. The groups both trained 3 times per week. This included 4 × 30-m and 4 × 50-m maximum effort sprints, with a recovery time of 4–6 minutes, respectively. There was a 10-minute recovery time between the last 30-m sprint and the first 50-m sprint. The resistance applied in this study was a large parachute and was adjusted accordingly so that running velocity per 30- to 50-m set was not allowed to exceed a 10% reduction in the subjects' unresisted sprint time for that distance. The resisted group improved significantly over various sprint distances, both

TABLE 3. Description of treatment and control group training.*

Author		Kamandulis et al. (30)	Balsalobre-Fernandez et al. (4)	Martinopoulou et al. (37)	Blazevich and Jenkins (5)	Satkunskienė et al. (50)
Treatment group/ control group	Locomotor training	PE = 60–90% of max for 20 s 5–10 times (0.5- to 1-min rest); vertical jumps; multiple forward jumps; running exercises (hurdles, upstairs, uphill, and on spot); sprints alternating with slow jogging; HP = 95–100% of max for 5–10 s 5–10 times (5-min rest); runs with weight belt; 1-step vertical jumps; forward jumps; crouch-start running; dynamic inertial loads		>10% decrease in running velocity (parachute); experimental group; maximum sprints with parachute; 4 × 30 m with 4-min rest; 10-min rest between 4 × 50 with 6-min rest; CT = maximum sprints; unresisted training (no parachute); 4 × 30 m with 4-min rest; 10-min rest; 4 × 50 with 6-min rest		PE, standing jumps, multiple hops and jumps, barrier hops, run up stairs, run up hill, run in place; exercise intensity = 60–90%, duration–20 s, 5–10 repetitions with 30- to 60-s passive rest. The PT resisted sled-pulling sprinting, depth jump, multiple hops and jumps, block start run, and exercises for muscle strength: lever-seated calf raise, Barbell back extension, Pec Deck butterfly's, lever-lying leg curl. Exercise intensity = 100%, duration–10 s, 5–7 repetitions with 3- to 5-min passive rest, 5-min rest between sets
	Stationary training	Vertical jumps	40% of 1RM + increments of 5% until max power was attained (Myotest Pro); squat jumps		Squat hip extension; leg extension; hip flexion; leg flexion	Lever-seated calf raise, Barbell back extension, Peck Deck butterfly's, lever-lying leg curl
	Frequency	6–9 h a wk; power endurance, 3 wk; recovery, 1 wk; PT, 4 wk; total 8 wk (27 sessions)	2 times per wk; total 10 wk	3 times per wk; total 4 wk	2 times per wk; 4 wk standardization training; 7 wk RT; total 7 wk	3 times per wk; 4 wks power endurance; 4 wk PT; total 8 wk

*PE = power endurance training; HP = high-intensity power training; CT = control trial; PT = power training; 1RM = 1 repetition maximum; RT = resistance training.

in the acceleration phase and in the maximum speed phase; 0–10 m ($p = 0.043$), 10–20 m ($p = 0.017$), 0–20 m ($p = 0.009$), and 40–50 m ($p = 0.023$). The unresisted control group showed no significant improvements over the same distances with the exception of the acceleration phase 0–20 m ($p = 0.012$). The findings suggest that the parachute seems to be a suitable training method for performance improvement in the acceleration phase and maximum speed phase in sprinting.

Blazevich and Jenkins (5) also scored a 7/11 on the PEDro scale as a result of using random group allocation. Blazevich and Jenkins (5) considered the effect of speed of resistance training exercises on competitive nationally ranked sprinters ($n = 10$). The intervention consisted of 4-week standardization training to ensure homogeneity between groups by controlling the velocity of the movements before the trial. Movement velocities for this period were noted as being slow, with eccentric and concentric phases lasting 1–2 seconds. This was followed by 7 weeks of resistance training with high- and low-velocity groups. The results did not demonstrate any significant difference between groups. There was a 1.9% improvement in sprinting performance ($p = 0.08$; ES = 0.71) in the high-velocity group with respect to the flying 20-m sprint. The authors suggested resistance training movement speed does not have a significant effect on sprint performance when the resistance training is combined with sprint training in nationally ranked athletes. Blazevich and Jenkins (5) also suggest that its effects would only be significant after longer training periods, due to the level of the athlete's current adaptation to resistance, the emphasis placed on specific sprint training on the track, and the short period of time spent resistance training.

Satkunskienė et al. (50) scored a 6/11 on the PEDro scale due to the lack of random allocation concealment and blinding. Satkunskienė et al. (50) studied the effect of a power training program on running kinematics. Seven elite sprinters participated in the study 3 times per week over an 8-week period. The program comprised initial 4 weeks of power endurance training at 60–90% of 1RM with 30- to 60-second rest between exercises, followed by 4 weeks of power training at 100% of 1RM with 3- to 5-minute rest between exercises.

The power endurance training consisted of standing jumps, multiple hops and jumps, barrier hops, stair runs, uphill runs, and runs on the spot. The intensity was set at 60–90% intensity, and the training comprised of 20 seconds bouts of activity with 30- to 60-second passive rest in between exercises. The power training consisted of resisted sled-pulling sprints, depth jumps, multiple hops and jumps, block starts, and a selection of other assistance exercises (lever-seated calf raise, barbell back extension, machine fly, butterfly, and lever-lying leg curl). The intensity was set at 100% of 1RM with 10-second activity bouts and 3- to 5-minute recovery between exercises. The results indicated some improvement but no significant increase in maximal running speed (pre = 9.62 ± 0.35 seconds, post = 10.0 ± 0.57 seconds, $p = 0.08$), ground contact (pre = 119 ± 15.39 seconds, post = 115 ± 10.41 seconds, $p = 0.50$), step length (pre = 2.24 ± 0.16 m, post = 2.28 ± 0.19 m, $p = 0.69$), and step frequency (pre = 4.31 ± 0.39 seconds, post = 4.42 ± 0.37 seconds, $p = 0.19$). There were no significant differences in many of the other parameters, including joint angles, hip flexion, and foot trajectory.

Discussion

The current review addresses the question of resistance training modalities and performance outcome for sprint athletes. This review is unique because of its narrow focus on competitive sprinters, similar to an investigation by Yamamoto et al. (62) on the effects of resistance training on high-level endurance athletes. It comprehensively reviews the literature in the area and includes a systematic review with, PEDro scaling, and protocols used. This systematic review of 5 resistance training studies suggests that a varied input in the form of locomotor resistance (involving unilateral movement, 2–4 times per week, ranging from 60 to 100% intensities) and fixed plane resistance (involving bilateral movement, 2–4 times per week, ranging from 30 to 90% 1RM) can provide for improved sprinting performance. These ranges do not provide specific direction for a sprint coach, but the variety of movements emphasizes that a varied input can produce similar performance outcomes. The moderate PEDro scale scores (6–7) should not diminish the quality of the reviewed studies, considering the constraints that training studies have in blinding subjects, therapists (i.e., trainers), and assessors to the treatment received.

Despite the volume of sprint studies available, few have focused specifically on competitive sprinters. One limitation of this review was the small number of studies that met the inclusion criteria, but this further emphasizes that competitive sprint coaches are using various methods of resistance training with unpublished empirical evidence to substantiate the type, frequency, and programming of these activities. Furthermore, the ceiling effect is relevant here as subjects reviewed may have reached a maximal level of strength and power, thus demonstrated smaller improvements in performance. Although the studies included provide evidence that resistance training improves sprinting performance, further research is needed to elucidate the most effective combinations of training methods for optimal transference and the most effective programming models to elicit improved performance. It is noteworthy that the reviewed studies show a varied input of resistance from that of a locomotor resistance to that of a fixed plane resistance with similar performance outcome improvements. It is also worth nothing that all groups used exercises of a dynamic or explosive nature, with the exception of the study by Blazevich and Jenkins (5). Sprint performance therefore may be optimized by a variety of resistance training modalities.

Despite the link between resistance training and sprinting performance in these studies, 3 of the studies (30,37,50) used predominantly locomotor type resistance training such as plyometrics, horizontal jumping patterns, antiphase movement (unilateral), and stair climbs, whereas the remaining 2 studies (4,5) used fixed plane resistance movements like squat jumps and leg extensions. Two of the studies (30,50) used a combination of locomotor training and fixed plane resistance, which is mentioned by de Villarreal et al. (11), with similarly successful findings. Additionally, while all of the studies in this review consisted of relatively short training periods (average = 7.4 weeks), it is unknown how chronic adaptations to these training methods will affect sprinting performance. Acute improvements in running with resistance training are posited to be associated with neuromuscular adaptations (11,26,62), but the effects of chronic resistance training on muscle mass, muscle metabolic activity, or the risk benefit is still unknown. Because the studies in this review assessed competitive sprinters, it was probably difficult to control training for a longer period of time because of the competitive season (62).

To disseminate the results of resistance-based training for sprinters, researchers must consider the different modalities of training available. First, general physical preparation, which involves general conditioning to improve strength, speed, endurance, flexibility, and skill followed by more specific training, which aims to improve the individual athlete's performance (52). Second, the modality of resistance training, fixed plane resistance training (e.g., squat, deadlift, and bench press) with the option of open and closed chain movements, which has been studied extensively in the broader literature (5,11,25,26,45,49,62), or locomotor resistance training. Locomotor resistance training has been the most frequently studied among competitive sprinters. The population sample remains too small to form conclusive opinion on locomotor resistance training benefit over traditional sprint training on a track (4,5,30,37,50). It is unclear which forms show the optimal transference to sprinting performance. There are many ways of developing relative strength (52), but it remains unclear whether locomotor resistance or fixed plane resistance show greater transference to sprinting performance. The muscle activation of these movements will reveal more about which exercise mimics the muscle activation, neural adaptations, and neural sequencing required to facilitate maximum speed performance outcomes in competitive sprinters. Future research here is certainly warranted.

Practical Applications

This research supports increased sprinting performance with resistance-based training programs involving unilateral movement, 2–4 times per week at 60–100% of 1RM. The importance of a general strength base in conjunction with dynamically oriented strength programming forms the basis for training competitive sprinters. This review illustrates how different modalities of resistance training result in similar performance improvements yet there is no clear modality, which stands out as being optimal for speed development.

Coaches should use structured, periodized resistance training regimens based on the health and ability of individual athletes during each training phase. The positive benefits of resistance-based training in sprinters cannot be overlooked despite the limited body of empirical evidence. However, it is evident that there is a need for further research with highly trained competitive sprinters on the potential benefits of various forms of resistance-based training on sprinting performance. This article illustrates the need for further research within the sprinting population regarding the specificity of different resistance training modalities to sprinting performance. Research needs to determine whether there is true transference between many of the resistance-based exercises used in sprint training, from both a neural activation and overall adaptation point of view.

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