BRIEF REVIEW

Effect of Different Sprint Training Methods on Sprint Performance Over Various Distances: A Brief Review

Michael C. Rumpf,[1,2] Robert G. Lockie,[3] John B. Cronin,[1,4] and Farzad Jalilvand[3]

[1]*Sport Performance Research Institute New Zealand, AUT University, Auckland, New Zealand;* [2]*National Sports Medicine Programme, Excellence in Football Project, Aspetar, Qatar Orthopaedic and Sports Medicine Hospital, Doha, Qatar;* [3]*Department of Kinesiology, California State University, Northridge, Northridge; and* [4]*School of Exercise, Biomedical and Health Sciences, Edith Cowan University, Joondalup, Australia*

Abstract

Rumpf, MC, Lockie, RG, Cronin, JB, and Jalilvand, F. Effect of different sprint training methods on sprint performance over various distances: a brief review. *J Strength Cond Res* 30(6): 1767–1785, 2016—Linear sprinting speed is an essential physical quality for many athletes. There are a number of different training modalities that can be used to improve sprint performance. Strength and conditioning coaches must select the most appropriate modalities for their athletes, taking into consideration the sprint distances that typically occur during competition. The study purpose was to perform a brief review as to the effect of specific (free sprinting; resisted sprinting by sleds, bands, or incline running; assisted sprinting with a towing device or a downhill slope), nonspecific (resistance and plyometric training), and combined (a combination of specific and nonspecific) training methods on different sprint distances (0–10, 0–20, 0–30, and 31+ m). A total of 48 studies fulfilled the inclusion criteria, resulting in 1,485 subjects from a range of athletic backgrounds. The training effects associated with specific sprint training were classified as moderate (effect size [ES] = −1.00; %change = −3.23). Generally, the effect of specific sprint training tended to decrease with distance, although the largest training effects were observed for the 31+ m distance. The greatest training effects (ES = −0.43; %change = −1.65) of nonspecific training were observed for the 31+ m distance. The combined training revealed greatest effects (ES = −0.59; %change = −2.81) for the 0–10 m distance. After this review, specific sprint training methods seem the most beneficial over the investigated distances. However, the implementation of nonspecific training methods (e.g., strength and power training) could also benefit speed and athletic performance.

Key Words speed training, training specificity, acceleration, maximal velocity, resisted and assisted sprinting

Introduction

Sprint ability is an important factor in a range of athletic activities and in many instances can define performance success. A specific example can be seen in the 100-m track and field sprint event, where the fastest sprinter will typically win the race (31). However, quicker athletes will have an advantage in team sports as well. For example, faster soccer players should be able to reposition themselves more quickly during crucial match situations, such as contests for the ball (80) and goal-scoring opportunities (28). Depending on the sport, the importance of speed can be affected by the distance traveled during a sprint effort. For strength and conditioning coaches, understanding the number of sprints and associated distances is important for sport-specific speed development.

Previous research has emphasized the value of acceleration (i.e., sprints of less than 20 m) for field sport athletes (27,54,88). For example, most (approximately 68%) sprint distances in professional rugby league were less than 20 m (30). To further illustrate the importance of short sprint speed, Gabbett (30) stated that the most common (approximately 46%) sprint distance for the positional grouping of hit-up forwards was 6–10 m, which emphasizes the ability to accelerate. Similar values for average sprinting distances were obtained for professional elite rugby union players (3), whereas Australian state-level cricket players cover between 10-17 m per sprint in 20-20 games (76). In professional soccer players, various researchers have reported that players sprint a total distance of between 200 and 1,100 m during a match (1,8,70,77). However, the mean duration of sprints completed during a soccer match is very short, tending to be between 2 and 4 seconds (90). This results in mean sprint distances of approximately 10–30 m (78), with most sprints being shorter than 20 m (26).

Address correspondence to Michael C. Rumpf, rumpf.michael@web.de.

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Table 1. Specific sprint training studies.

Investigation	No. subjects	Population: age, training status	Training: sessions per week (no.), duration (wk), total amount (no.)	Outcome measures (m)	Training effect		Training efficacy		Qualitative inference
					Percent change (%)	Effect size	Percent change (%)	Effect size	
Free sprinting									
Callister et al. (13)	12	23.2 (±1.0), subjects, sprinting	3, 8, 24	0–30	−1.31	−0.67	−0.05	−0.03	Moderate
Callister et al. (13)	12	23.2 (±1.0), subjects, sprinting	3, 8, 24	0–100	−4.51	−2.06	−0.19	−0.09	Very large
Dawson et al. (23)	9	22.0 (±2.0), healthy active males, sprinting	2.6, 6, 16	0–10	−3.21	−3.00	−0.21	−0.19	Very large
Dawson et al. (23)	9	22.0 (±2.0), healthy active males, sprinting	2.6, 6, 16	0–40	−2.36	−2.60	−0.17	−0.15	Very large
Lockie et al. (56)	9	23.3 (±4.2), physically active field sport athletes, sprinting	2, 6, 12	0–5	−6.02	−1.14	−0.50	−0.10	Moderate
Lockie et al. (56)	9	23.3 (±4.2), physically active field sport athletes, sprinting	2, 6, 12	0–10	−4.33	−0.75	−0.36	−0.06	Moderate
Majdell and Alexander (61)	6	21.0 (±3.5), varsity football players, sprinting	3, 6, 18	0–40	−0.73	−0.12	−0.01	−0.04	Trivial
Rimmer and Sleivert (81)	7	24.0 (±4.0), healthy males, sprinting	2, 8, 16	0–10	−1.03	−0.33	−0.06	−0.02	Small
Rimmer and Sleivert (81)	7	24.0 (±4.0), healthy males, sprinting	2, 8, 16	0–40	−1.25	−0.50	−0.08	−0.03	Small
Spinks et al. (89)	10	21.8 (±4.2), first grade football players, sprinting	2, 8, 16	0–5	−7.04	−0.77	−0.44	−0.05	Moderate
Spinks et al. (89)	10	21.8 (±4.2), first grade football players, sprinting	2, 8, 16	0–15	−5.82	−0.89	−0.36	−0.06	Moderate
Zafeiridis et al. (100)	11	20.1 (±1.9), physical education students, sprinting	3, 8, 24	0–10	0.56	0.50	0.02	0.02	Negative
Zafeiridis et al. (100)	11	20.1 (±1.9), physical education students, sprinting	3, 8, 24	0–20	0.66	0.67	0.03	0.03	Negative
Resisted sprinting									
Kawamori et al. (49)	10	22.8 (±3.3), physically active people, heavy load group	2, 8, 16	0–5	−5.47	−1.17	−0.34	−0.07	Very large
Kawamori et al. (49)	10	22.8 (±3.3), physically active people, heavy load group	2, 8, 16	0–10	−5.37	−1.57	−0.34	−0.10	Very large
Kawamori et al. (49)	11	22.3 (±5.2), physically active people, light load group	2, 8, 16	0–5	−3.13	−0.50	−0.20	−0.03	Very large
Kawamori et al. (49)	11	22.3 (±5.2), physically active people, light load group	2, 8, 16	0–10	−2.91	−0.60	−0.18	−0.04	Very large
Lockie et al. (56)	9	23.3 (±4.2), physically active field sport athletes, resisted sprinting	2, 6, 12	0–5	−6.11	−0.80	−0.51	−0.07	Moderate
Lockie et al. (56)	9	23.3 (±4.2), physically active field sport athletes, resisted sprinting	2, 6, 12	0–10	−5.26	−0.79	−0.44	−0.07	Moderate

Zafeiridis et al. (100)	11	20.1 (±1.9), physical education students, resisted sprinting	3, 8, 24	0–10	−3.95	−3.50	−0.16	−0.15	Very large
Zafeiridis et al. (100)	11	20.1 (±1.9), physical education students, resisted sprinting	3, 8, 24	0–20	−3.00	−1.98	−0.12	−0.08	Very large
Assisted sprinting									
Majdell and Alexander (61)	6	23.0 (±2.7), varsity football players, assisted sprinting	2, 6, 18	0–40	−1.60	−0.31	−0.09	−0.02	Small

Although it is clear that speed over short distances is a requirement for most team sport athletes, a high maximal running velocity is also an important trait. Maximal velocity for team sport athletes is typically achieved during a longer sprint of 30–40 m (27,93,98). This has value to athletes, as maximal sprints in team sports can often be initiated from a moving start (27). Although sprints of these distances are less frequent in match play (26,46), athletes could have the opportunity to attain maximal velocity during a sprint effort if they begin the sprint while moving. This suggests that despite the importance of acceleration development for most athletes, speed over longer distance sprints (i.e., 30 m or greater) should also be developed. On the basis of these collective research findings, strength and conditioning coaches should therefore use distance-specific training for their athletes when looking to enhance speed.

To improve the speed qualities associated with various sports, coaches implement various types of training modalities (e.g., free, assisted, and resisted sprinting, resistance training, and plyometrics) (20,56). However, despite the widespread use of many training methods, there is limited information as to whether certain protocols are better used to induce speed improvements over specific distances (i.e., shorter or longer distance sprints). For this reason, it would be of great benefit for strength and conditioning coaches to have a resource that centralizes information regarding different speed training protocols and how they influence sprint performance over various distances.

Therefore, the purpose of this study was to perform a brief review and investigate the current scientific literature to quantify the effect of different training methods on sprint times over various sport-specific distances. The sprint distances investigated were 0–10, 0–20, 0–30, and 31+ m. As will be documented, these distances were investigated as they have been commonly used within the scientific literature and have application for team sport athletes. In this review, training studies were categorized into specific sprint training (free sprint, resisted, and assisted training methods); nonspecific training methods (strength, power, and plyometric training), and combined training methods, which is a mixture of specific and nonspecific methods. This brief review will document the speed training protocols established within the literature as being able to enhance sprint performance. More importantly, this study will highlight the protocols that could be used to improve speed over specific distances for athletes.

Methods

Study Selection

To obtain articles for the review, a database search of PubMed, Google Scholar, SPORTDiscus, and MEDLINE was conducted at the end of October 2014. The bibliographies of all reviewed articles were then searched and reviewed. Studies were chosen for inclusion if they fulfilled the following 7 selection criteria: (a) the study used a training

TABLE 2. Specific sprint training and its effect on different distances.*

					Training effect		Training efficacy	
Distance (m)	Type of training	No. studies	No. groups	No. participants	ES ± *SD*	%change ± *SD*	ES ± *SD*	%change ± *SD*
0–10	Summary	7	13	126	−1.11 ± 1.07	−4.10 ± 2.15	−0.07 ± 0.05	−0.29 ± 0.17
	Free sprinting	5	6	55	−0.92 ± 1.17	−3.51 ± 2.91	−0.07 ± 0.07	−0.26 ± 0.21
	Resisted sprinting	3	7	71	−1.28 ± 1.05	−4.60 ± 1.26	−0.08 ± 0.04	−0.31 ± 0.14
	Assisted sprinting							
0–20	Summary	7	16	158	−1.10 ± 1.17	−3.77 ± 2.37	−0.07 ± 0.06	−0.26 ± 0.18
	Free sprinting	5	8	76	−0.71 ± 1.13	−3.28 ± 3.04	−0.05 ± 0.07	−0.24 ± 0.21
	Resisted sprinting	3	8	82	−1.49 ± 1.14	−4.27 ± 1.49	−0.08 ± 0.04	−0.28 ± 0.15
	Assisted sprinting							
0–30	Summary	7	17	170	−1.08 ± 1.14	−3.63 ± 2.37	−0.07 ± 0.06	−0.25 ± 0.18
	Free sprinting	6	9	88	−0.71 ± 1.06	−3.06 ± 2.92	−0.05 ± 0.07	−0.21 ± 0.21
	Resisted sprinting							
	Assisted sprinting							
31+	Summary	4	5	40	−1.12 ± 1.13	−2.11 ± 1.47	−0.06 ± 0.07	−0.11 ± 0.06
	Free sprinting	4	4	34	−1.32 ± 1.20	−2.21 ± 1.68	−0.08 ± 0.07	−0.12 ± 0.07
	Resisted sprinting							
	Assisted sprinting	1	1	6	−0.31	−1.69	−0.02	−0.09

*ES = effect size.

Table 3. Nonspecific sprint training studies.

Investigation	No. subjects	Population: age, training status	Training: sessions per week (no.), duration (wk), total amount (no.)	Outcome measures (m)	Training effect: Percent change (%)	Training effect: Effect size	Training efficacy: Percent change (%)	Training efficacy: Effect size	Qualitative inference
Plyometric training									
Chelly et al. (15)	12	19.1 (±0.7), regional soccer team, plyometric training	2, 8, 16	0–5	−8.80	−0.69	−0.55	−0.04	Moderate
Impellizzeri et al. (45)	18	25.0 (±4.0), recreational soccer players, plyometric training	3, 4, 12	0–10	−3.70	−0.87	−0.31	−0.07	Moderate
Impellizzeri et al. (45)	19	25.0 (±4.0), recreational soccer players, plyometric training	3, 4, 12	0–10	−4.26	−0.89	−0.31	−0.07	Moderate
Impellizzeri et al. (45)	18	25.0 (±4.0), recreational soccer players, plyometric training	3, 4, 12	0–20	−2.79	−1.13	−0.23	−0.09	Moderate
Impellizzeri et al. (45)	19	25.0 (±4.0), recreational soccer players, plyometric training	3, 4, 12	0–20	−2.51	−0.53	−0.21	−0.04	Small
Lockie et al. (56)	9	23.3 (±4.2), physically active field sport athletes, plyometric training	2, 6, 12	0–5	−5.30	−1.17	−0.44	−0.10	Moderate
Lockie et al. (56)	9	23.3 (±4.2), physically active field sport athletes, plyometric training	2, 6, 12	0–10	−3.85	−0.80	−0.32	−0.07	Moderate
Nakamura et al. (74)	11	22.7 (±2.4), regional/semiprofessional soccer team players, plyometric training	2, 3, 6	0–5	7.14	1.00	1.19	0.17	Negative
Nakamura et al. (74)	11	22.7 (±2.4), regional/semiprofessional soccer team players, plyometric training	2, 3, 6	0–10	4.62	1.00	0.77	0.17	Negative
Nakamura et al. (74)	11	22.7 (±2.4), regional/semiprofessional soccer team players, plyometric training	2, 3, 6	0–20	3.30	0.83	0.55	0.14	Negative
Reyment et al. (79)	17	20.9 (±2.0), division III collegiate athletes, plyometric training	2, 8, 16	0–9.1	−0.18	−0.07	−0.02	−0.01	Trivial
Reyment et al. (79)	17	20.9 (±2.0), division III collegiate athletes, plyometric training	2, 8, 16	0–36.6	−0.14	−0.03	−0.02	0.00	Trivial

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Rimmer and Sleivert (81)	10	24.0 (±4.0), healthy males, plyometric training	2, 8, 16	0–10	−2.55	−0.50	−0.16	−0.03	Small
Rimmer and Sleivert (81)	10	24.0 (±4.0), healthy males, plyometric training	2, 8, 16	0–40	−1.78	−0.56	−0.11	−0.03	Small
Saez de Villarreal et al. (85)	9	20.4 (±2.1), physical education students, plyometric training	3, 7, 21	0–15	−0.70	0.13	−0.03	0.01	Negative
Saez de Villarreal et al. (85)	9	20.4 (±2.1), physical education students, plyometric training	3, 7, 21	0–30	−0.91	−0.14	−0.04	−0.01	Trivial
Salonikidis and Zafeiridis (86)	16	21.1 (±1.3), novice tennis players, untrained, plyometric training	3, 9, 27	0–4.12	−1.49	−0.13	−0.06	0.00	Trivial
Salonikidis and Zafeiridis (86)	16	21.1 (±1.3), novice tennis players, trained, plyometric training	3, 9, 27	0–4.12	−7.97	−0.79	−0.30	−0.03	Moderate
Salonikidis and Zafeiridis (86)	16	21.1 (±1.3), novice tennis players, untrained, plyometric training	3, 9, 27	0–11.89	0.41	0.05	0.02	0.00	Negative
Salonikidis and Zafeiridis (86)	16	21.1 (±1.3), novice tennis players, trained, plyometric training	3, 9, 27	0–11.89	−1.21	−0.15	−0.04	−0.01	Trivial
Wilson et al. (96)	16	22.1 (±6.8), weight training experienced athletes, plyometric training	2, 5, 10	0–30	0.43	0.05	0.04	0.00	Negative
Wilson et al. (96)	16	22.1 (±6.8), weight training experienced athletes, plyometric training	2, 10, 20	0–30	−0.22	−0.03	−0.01	0.00	Trivial
Strength training									
Askling et al. (2)	15	24.0 (±2.6), professional soccer players, resistance training	1.6, 10, 16	0–30	−2.38	−0.80	−0.15	−0.05	Moderate
Blazevich and Jenkins (9)	10	19.0 (±1.4), nationally ranked sprinters, low-velocity group	2, 7, 14	0–20	−2.94	−0.94	−0.21	−0.07	Moderate
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, strength group	3, 5, 15	0–5	1.72	0.25	0.11	0.02	Negative
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, strength group	3, 10, 30	0–5	−1.72	−0.33	−0.06	−0.01	Small
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, strength group	3, 5, 15	0–10	2.08	0.40	0.14	0.03	Negative
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, strength group	3, 10, 30	0–10	0.00	0.00	0.00	0.00	Trivial
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, strength group	3, 5, 15	0–20	0.00	0.00	0.00	0.00	Trivial
Cormie et al. (11)	8	23.9 (±4.8), relatively weak men, strength group	3, 10, 30	0–20	−0.91	−0.23	−0.03	−0.01	Small

Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, strength group	3, 5, 15	0–30	−0.44	−0.12	−0.03	−0.01	Trivial
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, strength group	3, 10, 30	0–30	−1.31	−0.37	−0.04	−0.01	Small
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, strength group	3, 5, 15	0–40	−1.02	−0.33	−0.07	−0.02	Small
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, strength group	3, 10, 30	0–40	−2.04	−0.67	−0.07	−0.02	Moderate
Deane et al. (24)	13	21.1 (±1.9), physically active college volunteers, resistance	3, 8, 24	0–9.1	−11.46	−1.32	−0.48	−0.06	Large
Deane et al. (24)	13	21.1 (±1.9), physically active college volunteers, resistance	3, 8, 24	0–36.6	−4.39	−0.68	−0.18	−0.03	Moderate
Harris et al. (35)	13	19.4 (±0.4), university football players, high-force group	4, 9, 36	0–9.1	1.04	0.75	0.03	0.02	Negative
Harris et al. (35)	13	19.4 (±0.4), university football players, high-force group	4, 9, 36	0–30	0.00	0.00	0.00	0.00	Trivial
Harris et al. (37)	7	21.8 (±4.0), rugby league player, 80% 1 repetition maximum group	1.86, 7, 13	0–10	−2.73	−1.00	−0.21	−0.08	Moderate
Harris et al. (37)	7	21.8 (±4.0), rugby league player, 80% 1 repetition maximum group	1.86, 7, 13	0–30	−1.67	−0.58	−0.13	−0.04	Small
Helgerud et al. (39)	21	25.0 (±2.9), premier league soccer players, resistance training	2, 8, 16	0–10	−3.21	−0.86	−0.20	−0.05	Moderate
Helgerud et al. (39)	21	25.0 (±2.9), premier league soccer players, resistance training	2, 8, 16	0–20	−2.00	−0.57	−0.12	−0.04	Moderate
Hoffman et al. (42)	9	18.8 (±0.7), NCAA division I basketball players, resistance training	3, 5, 15	0–27	−2.00	−0.38	−0.13	−0.03	Small
Lockie et al. (56)	9	23.3 (±4.2), physically active field sport athletes, resistance	2, 6, 12	0–5	−8.82	−2.40	−0.74	−0.20	Very large
Lockie et al. (56)	9	23.3 (±4.2), physically active field sport athletes, resistance	2, 6, 12	0–10	−6.60	−2.33	−0.55	−0.19	Very large
Los Arcos et al. (58)	7	20.3 (±1.9), professional football players, strength training with vertical only component	1–2, 8, 11	0–5	−1.03	−0.20	−0.09	−0.02	Moderate
Los Arcos et al. (58)	7	20.3 (±1.9), professional football players, strength training with vertical only component	1–2, 8, 11	0–15	−0.43	−0.11	−0.04	−0.01	Small

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Los Arcos et al. (58)	8	19.6 (±1.6), professional football players, strength training with vertical only component	1–2, 8, 11	0–5	−1.03	−0.33	−0.09	−0.03	Moderate
Los Arcos et al. (58)	8	19.6 (±1.6), professional football players, strength training with vertical only component	1–2, 8, 11	0–15	−0.87	−0.25	−0.08	−0.02	Small
Moir et al. (71)	10	18.9 (±1.7), physically active men, resistance training	3, 8, 24	0–10	5.98	0.85	0.25	0.04	Negative
Moir et al. (71)	10	18.9 (±1.7), physically active men, resistance training	3, 8, 24	0–20	0.62	0.12	0.03	0.00	Negative
Murphy and Wilson (73)	14	22.0 (±4.0), healthy male subjects, resistance training	2, 8, 16	0–40	−2.23	−0.36	−0.14	−0.02	Small
Ronnestad et al. (82)	6	22.0 (±2.5), Norwegian professional soccer players, resistance training	2, 7, 14	0–10	−1.68	−1.00	−0.12	−0.07	Moderate
Ronnestad et al. (82)	6	22.0 (±2.5), Norwegian professional soccer players, resistance training	2, 7, 14	0–40	−1.29	−0.88	−0.09	−0.06	Moderate
Saez de Villarreal et al. (85)	12	20.4 (±2.1), physical education students, heavy resistance exercise nonballistic	3, 7, 21	0–15	−0.80	−0.12	−0.04	−0.01	Trivial
Saez de Villarreal et al. (85)	12	20.4 (±2.1), physical education students, heavy resistance exercise nonballistic	3, 7, 21	0–30	0.13	0.03	0.01	0.00	Trivial
Wilson et al. (96)	16	21.9 (±5.8), weight training experienced athletes, resistance training	2, 5, 10	0–30	1.13	0.21	0.11	0.02	Negative
Wilson et al. (96)	16	21.9 (±5.8), weight training experienced athletes, resistance training	2, 10, 20	0–30	−0.23	−0.04	−0.01	0.00	Trivial
Wilson et al. (95)	14	18.9 (±1.7), exercise science students, resistance training	2, 8, 16	0–40	−2.33	−0.36	−0.14	−0.02	Small
Power training									
Blazevich and Jenkins (9)	10	19.0 (±1.4), nationally ranked sprinters, high-velocity group	2, 7, 14	0–20	−4.31	−0.76	−0.31	−0.05	Moderate
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, power group	3, 5, 15	0–5	−3.42	−0.33	−0.23	−0.02	Small
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, power group	3, 10, 30	0–5	−6.84	−0.67	−0.23	−0.02	Moderate
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, power group	3, 5, 15	0–10	−2.56	−0.31	−0.17	−0.02	Small
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, power group	3, 10, 30	0–10	−4.62	−0.56	−0.15	−0.02	Small

Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, power group	3, 5, 15	0–20	−2.41	−0.42	−0.16	−0.03	Small
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, power group	3, 10, 30	0–20	−4.22	−0.74	−0.14	−0.02	Moderate
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, power group	3, 5, 15	0–30	−1.96	−0.39	−0.13	−0.03	Small
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, power group	3, 10, 30	0–30	−3.48	−0.70	−0.12	−0.02	Moderate
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, power group	3, 5, 15	0–40	−1.86	−0.41	−0.12	−0.03	Small
Cormie et al. (17)	8	23.9 (±4.8), relatively weak men, power group	3, 10, 30	0–40	−3.56	−0.78	−0.12	−0.03	Moderate
Harris et al. (35)	16	18.5 (±0.2), university football players, high-power group	4, 9, 36	0–9.1	1.67	1.25	0.03	0.05	Negative
Harris et al. (35)	16	18.5 (±0.2), university football players, high-power group	4, 9, 36	0–30	0.68	0.75	0.02	0.02	Negative
Harris et al. (37)	7	21.8 (±4.0), rugby league player, maximal power group	1.86, 7, 13	0–10	−1.61	−0.43	−0.12	−0.03	Small
Harris et al. (37)	7	21.8 (±4.0), rugby league player, maximal power group	1.86, 7, 13	0–30	−1.18	−0.28	−0.09	−0.02	Small
Harris et al. (35)	13	19.4 (±0.4), university football players, combined group	4, 9, 36	0–9.1	−2.30	−1.40	−0.06	−0.04	Large
Harris et al. (35)	13	19.4 (±0.4), university football players, combined group	4, 9, 36	0–30	−1.36	−0.75	−0.04	−0.02	Moderate
Hoffman et al. (41)	10	19.3 (±1.2), NCAA division III football players, olympic lift group	4, 15, 60	0–36.6	−1.41	−0.41	−0.02	−0.01	Small
Hoffman et al. (41)	10	18.9 (±1.4), NCAA division III football players, power lift group	4, 15, 60	0–36.6	−0.81	−0.25	−0.01	0.00	Small
Lyttle et al. (60)	11	23.9 (±6.4), recreational athletes, maximal power training	2, 8, 16	0–40	1.28	0.18	0.08	0.01	Negative
McBride et al. (65)	9	24.2 (±1.8), athletic men, light load jump squat group	2, 8, 16	0–5	−0.89	−0.33	−0.06	−0.02	Small
McBride et al. (65)	10	21.6 (±0.8), athletic men, heavy load jump squat group	2, 8, 16	0–5	6.42	2.33	0.40	0.15	Negative
McBride et al. (65)	9	24.2 (±1.8), athletic men, light load jump squat group	2, 8, 16	0–10	−1.57	−0.75	−0.10	−0.05	Moderate
McBride et al. (65)	10	21.6 (±0.8), athletic men, heavy load jump squat group	2, 8, 16	0–10	4.89	3.00	0.31	0.19	Negative
McBride et al. (65)	9	24.2 (±1.8), athletic men, light load jump squat group	2, 8, 16	0–20	−0.92	−0.60	−0.06	−0.04	Moderate
McBride et al. (65)	10	21.6 (±0.8), athletic men, heavy load jump squat group	2, 8, 16	0–20	1.57	1.00	0.10	0.06	Negative

(continued on next page)

McEvoy and Newton (66)	9	24.4 (±4.0), national baseball players, ballistic resistance training	1.5, 10, 13	0–27.4	−8.28	−1.85	−0.55	−0.12	Large
McMaster et al. (68)	6	20.9 (±2.5), highly trained rugby players, strength and heavy ballistic training	2, 10, 20	0–10	−1.14	−0.33	−0.06	−0.02	Small
McMaster et al. (68)	8	20.9 (±2.5), highly trained rugby players, strength and light ballistic training	2, 10, 20	0–10	−1.70	−0.75	−0.09	−0.04	Moderate
McMaster et al. (68)	6	20.9 (±2.5), highly trained rugby players, strength and heavy ballistic training	2, 10, 20	0–20	−0.99	−0.37	−0.05	−0.02	Small
McMaster et al. (68)	8	20.9 (±2.5), highly trained rugby players, strength and light ballistic training	2, 10, 20	0–20	−0.99	−0.37	−0.05	−0.02	Small
McMaster et al. (68)	6	20.9 (±2.5), highly trained rugby players, strength and heavy ballistic training	2, 10, 20	0–30	−0.71	−0.30	−0.04	−0.02	Small
McMaster et al. (68)	8	20.9 (±2.5), highly trained rugby players, strength and light ballistic training	2, 10, 20	0–30	−0.72	−0.27	−0.04	−0.01	Small
Saez de Villarreal et al. (85)	12	20.4 (±2.1), physical education students, power orientated	3, 7, 21	0–15	−1.40	−0.24	−0.07	−0.01	Small
Saez de Villarreal et al. (85)	12	20.4 (±2.1), physical education students, power orientated	3, 7, 21	0–30	0.33	0.03	0.02	0.00	Trivial
Tricoli et al. (92)	7	22.0 (±1.5), physical education students, resistance and olympic weightlifting	3, 8, 24	0–10	−3.53	−0.92	−0.15	−0.04	Moderate
Tricoli et al. (92)	7	22.0 (±1.5), physical education students, resistance and vertical jumps	3, 8, 24	0–30	−0.13	−0.04	−0.01	0.00	Trivial
Wilson et al. (95)	16	23.7 (±5.8), weight training experienced athletes, power training	2, 5, 10	0–30	−1.10	−0.17	−0.11	−0.02	Trivial
Wilson et al. (95)	16	23.7 (±5.8), weight training experienced athletes, power training	2, 10, 20	0–30	−1.10	−0.17	−0.06	−0.01	Trivial

Table 4. Nonspecific sprint training and its effect on different distances.*

					Training effect		Training efficacy	
Distance (m)	Type of training	No. studies	No. groups	No. participants	ES ± *SD*	%change ± *SD*	ES ± *SD*	%change ± *SD*
0–10	Summary	18	39	410	−0.30 ± 1.05	−1.82 ± 4.21	−0.02 ± 0.08	−0.08 ± 0.34
	Strength training	9	14	135	−0.33 ± 0.95	−1.00 ± 3.91	−0.02 ± 0.07	−0.07 ± 0.24
	Power training	6	14	127	−0.01 ± 1.28	−1.23 ± 3.52	0.00 ± 0.07	−0.05 ± 0.19
	Plyometric training	7	11	148	−0.35 ± 0.74	−2.39 ± 4.84	−0.01 ± 0.09	−0.05 ± 0.54
0–20	Summary	21	61	657	−0.28 ± 0.89	−1.57 ± 3.52	−0.02 ± 0.07	−0.07 ± 0.29
	Strength training	11	22	219	−0.23 ± 0.84	−0.98 ± 3.41	−0.02 ± 0.06	−0.07 ± 0.21
	Power training	8	22	198	−0.12 ± 1.07	−1.40 ± 2.99	0.00 ± 0.06	−0.06 ± 0.16
	Plyometric training	8	17	240	−0.28 ± 0.70	−1.76 ± 4.12	−0.01 ± 0.08	−0.03 ± 0.46
0–30	Summary	24	85	925	−0.27 ± 0.79	−1.44 ± 3.14	−0.02 ± 0.06	−0.07 ± 0.25
	Strength training	14	31	320	−0.23 ± 0.75	−0.93 ± 3.05	−0.02 ± 0.05	−0.06 ± 0.19
	Power training	10	34	321	−0.20 ± 0.93	−1.47 ± 2.75	−0.01 ± 0.05	−0.07 ± 0.16
	Plyometric training	9	20	284	−0.24 ± 0.65	−1.53 ± 3.83	0.00 ± 0.08	−0.03 ± 0.42
31+	Summary	9	13	137	−0.43 ± 0.29	−1.65 ± 1.42	−0.02 ± 0.02	−0.08 ± 0.07
	Strength training	5	6	63	−0.55 ± 0.25	−2.20 ± 0.45	−0.03 ± 0.02	−0.11 ± 0.04
	Power training	3	5	47	−0.33 ± 0.35	−1.27 ± 1.75	−0.01 ± 0.02	−0.04 ± 0.08
	Plyometric training	2	2	27	−0.29 ± 0.37	−0.96 ± 1.16	−0.02 ± 0.02	−0.06 ± 0.07

*ES = effect size.

TABLE 5. Combined training studies.

Investigation	No. subjects	Population: age, training status	Training: sessions per week (no.), duration (wk), total amount (no.)	Outcome measures (m)	Training effect Percent change (%)	Training effect Effect size	Training efficacy Percent change (%)	Training efficacy Effect size	Qualitative inference
Faude et al. (29)	8	21.8 (±4.2), Swiss third division football team	2, 7, 14	0–10	0.00	0.00	0.00	0.00	None
Faude et al. (29)	8	21.8 (±4.2), Swiss third division football team	2, 7, 14	0–30	0.23	0.07	0.02	0.00	Negative
Herrero et al. (40)	8	20.9 (±2.5), physical education students	2, 4, 8	0–20	1.29	0.09	0.01	0.00	Negative
Hoffman et al. (43)	16	19.8 (±1.1), division III collegiate athletes, concentric/eccentric only group	0.93, 15, 14	0–36.6	−1.79	−0.29	−0.13	−0.02	Small
Hoffman et al. (43)	15	19.8 (±1.5), division III collegiate athletes, concentric/eccentric group	0.93, 15, 14	0–36.6	−0.40	−0.05	−0.03	0.00	Small
Hoffman et al. (43)	16	19.8 (±1.5), division III collegiate athletes, control group	0.93, 15, 14	0–36.6	−1.98	−0.36	−0.14	−0.03	Small
Kamandulis et al. (47)	7	20.7 (±1.8), national sprinters	3.9, 7, 27	0–60	−1.84	−0.59	−0.07	−0.02	Moderate
Lyttle et al. (60)	11	23.8 (±5.4), recreational athletes	2, 8, 16	0–40	−0.73	−0.18	−0.05	−0.01	Trivial
Majdell and Alexander (61)	6	19.0 (±1.4), varsity football players	3, 6, 18	0–40	−1.90	−0.71	−0.11	−0.04	Moderate
Ronnestad et al. (82)	8	23.0 (±2.0), Norwegian professional soccer players	2, 7, 14	0–10	−1.14	−1.00	−0.08	−0.07	Moderate
Ronnestad et al. (82)	8	23.0 (±2.0), Norwegian professional soccer players	2, 7, 14	0–40	−1.10	−1.00	−0.08	−0.07	Moderate
Saez de Villarreal et al. (85)	12	20.4 (±2.1), physical education students	3, 7, 21	0–15	−0.80	−0.14	−0.04	−0.01	Small
Saez de Villarreal et al. (85)	12	20.4 (±2.1), physical education students	3, 7, 21	0–30	−0.23	−0.03	−0.01	−0.04	Trivial
Spinks et al. (89)	10	21.8 (±4.2), first grade football players	2, 8, 16	0–5	−7.97	−1.10	−0.50	−0.07	Moderate
Spinks et al. (89)	10	21.8 (±4.2), first grade football players	2, 8, 16	0–15	−7.34	−1.50	−0.46	−0.09	Large
Tricoli et al. (92)	8	22.0 (±1.5), physical education students	3, 8, 24	0–10	−2.62	−0.45	−0.11	−0.02	Small
Tricoli et al. (92)	8	22.0 (±1.5), physical education students	3, 8, 24	0–30	−0.75	−0.15	−0.03	−0.01	Trivial
West et al. (94)	10	26.8 (±3.0), professional rugby players	2, 6, 12	0–10	−2.30	−0.40	−0.19	−0.03	Small
West et al. (94)	10	26.8 (±3.0), professional rugby players	2, 6, 12	0–30	−2.58	−0.39	−0.22	−0.03	Small

method described earlier as nonspecific, specific, or combined; (b) the study detailed the duration of the training and the training frequency per week; (c) the study clearly detailed the outcome measures of interest (e.g., 10-m sprint time) measured with appropriate equipment (i.e., timing gates or radar gun); (d) the study provided detailed information about the male participants (e.g., age >18 years, height, body mass, and training status); (e) the study presented group mean and *SD*s for the dependent variable (sprint time or average velocity) of up to 100 m before and after training, or the effect sizes (ESs) and calculated percent changes; (f) the study was published before October 2014; and (g) the study was written in English and published as a full-text article in a peer-reviewed journal.

Data Acquisition and Analysis

The following characteristics were recorded for all articles: author, year, sample size, age, training status, training methods, total amount of training sessions, duration of training intervention, number of sessions per week, testing distances, and training effect in percent change or ES. This review used a methodological approach that quantified the changes associated with a training intervention (83,84). Training studies have been categorized into specific sprint training (free sprint, resisted, and assisted training methods); nonspecific sprint training (strength, power, and plyometric training methods); and combined training (combination of specific and nonspecific methods). To further the analysis, specific and nonspecific training methods were also analyzed within their subcategories of free sprinting, resisted sprinting, assisted sprinting, strength training, power training, and plyometrics. Studies using strength training were based on high-force or nonballistic training. Power training studies were characterized by high-velocity or ballistic training, including Olympic lifting.

Percent changes (%change), ESs, and training efficacy (TE) were used to quantify the changes with each training intervention and sprint distance of 0–10, 0–20, 0–30, and 31+ m (i.e., >30 m until the end of sprint distance). The qualitative inferences associated with the ES that were used in this review were in accordance with Hopkins (44). An ES less than 0.2 was considered a trivial effect; 0.2–0.6, a small effect; 0.6–1.2, a moderate effect; 1.2–2.0, a large effect; 2.0–4.0, a very large effect; and 4.0 and above, an extremely large effect. Training efficacy was defined as the change in sprint time per session and calculated for all cited studies (67).

It should be noted that an improvement in sprint performance (i.e., a decrease in sprint time) is denoted as a negative ES. This approach allows the reader to make decisions about the practicality and efficacy of certain training methods in relation to other samples for potential inclusion into strength and conditioning programs. After the literature search, 48 studies satisfied the inclusion criteria. The analysis included 1,485 subjects, with an average age of 22.2 ± 3.00 years, height of 1.79 ± 0.06 m, and mass of 80.2 ± 8.80 kg.

Results

Specific Sprint Training

Specific sprint training methods comprised all training forms in which the athlete sprinted either (a) without any loading on a flat surface (i.e., free sprinting); (b) resisted by sleds, bands, or an uphill incline; or (c) assisted with a towing device or a downhill slope. In summary, a total of 8 studies (13,23,49,56,61,81,89,100) were included for analysis in this section. Two hundred ten subjects with an average age of 22.3 ± 3.18 years, height of 1.79 ± 0.06 m, and body mass of 79.9 ± 7.34 kg were included in this analysis.

Table 1 displays the data from the specific sprint studies investigated. A summary of the distance interaction for each of the specific sprint training methods from Table 1 can be observed in Table 2. The training effects associated with specific sprint training across all distances were generally classified as moderate (ES = ∼−1.10; %change = −3.40), with the greatest effect (ES = −1.12) observed for the 31+ m distance. Free sprinting had an average ES of −0.92 across all distances, and the greatest training effects were observed for the 31+ m distance. Training effects of resisted sprinting across all distances were classified as large, with an average ES of −1.39. The greatest ES for resisted sprinting was observed for the 0–20 m distance, and resisted sprinting

Table 6. Combined sprint training and its effect on different distances.*

	Training effect		Training efficacy	
	ES ± *SD*	%change ± *SD*	ES ± *SD*	%change ± *SD*
0–10 m	−0.59 ± 0.46	−2.81 ± 3.07	−0.04 ± 0.03	−0.18 ± 0.19
0–20 m	−0.56 ± 2.61	−2.61 ± 3.35	−0.04 ± 0.04	−0.15 ± 0.23
0–30 m	−0.42 ± 0.52	−2.02 ± 2.89	−0.03 ± 0.03	−0.12 ± 0.19
31+ m	−0.45 ± 0.33	−1.39 ± 0.64	−0.03 ± 0.02	−0.09 ± 0.04

*ES = effect size.

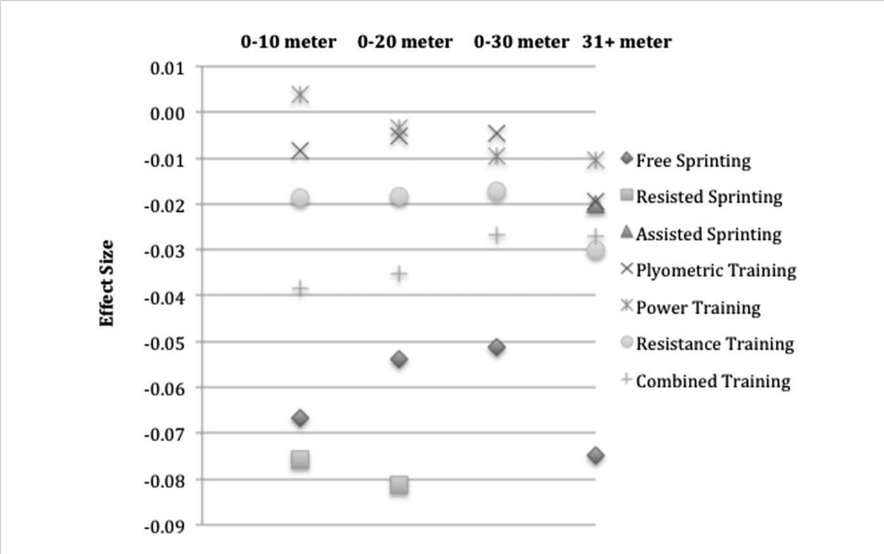

Figure 1. Training efficacy of each training method in different distances.

tended to show the greatest training effects of all specific sprint training methods. Assisted sprint training was only investigated over the 31+ m distance and showed a small effect (ES = −0.31). Additionally, the greatest TE was observed for resisted sprint training across distances 0–10 and 0–20 m, with an average ES of −0.08. Free sprinting provided the greatest TE over the 0–30 and 31+ m distances, with an average ES of −0.07.

Nonspecific Sprint Training

Strength and power-based training, in addition to plyometric training, were included as nonspecific forms of sprint training in this review. A total of 28 studies were included, in which 1,062 subjects (age = 22.1 ± 3.04 years, height = 1.79 ± 0.06 m, and body mass = 79.5 ± 8.93 kg) were included in the analysis. The data for all studies are presented in Table 3. Table 4 provides a summary of the distance interactions from the pooled and averaged data for the nonspecific sprint training methods. The combined nonspecific training effects across all distances were classified as small (average ES = −0.32; %change = −2.63). Although there was a tendency for the ES to decrease with distance (i.e., from 0–10 to 0–30 m), the greatest effect (ES = −0.43), although small, was observed for the 31+ m distance.

Similarly, the ES for strength training was classified as small (ES = 0.34) and tended to decrease as the sprint distance increased. However, the greatest ES (−0.55) was observed for the 31+ m distance. Power training had the lowest overall average effect (ES = −0.17) out of the nonspecific sprint training methods. Unlike strength training, the ES for power training increased with distance, with the greatest effect (ES = −0.33) observed for the 31+ m distance. Plyometric training had an average small ES of −0.29 over all distances. The greatest effect for plyometric training was observed for the 0–10 m distance (ES = −0.35; %change = −2.39).

Nonspecific sprint TE was −0.02 across all distances, and the greatest value was observed for strength training for the 31+ m distance. Average strength TE was −0.02 per session for all distances, whereas power training was most efficient for the 0–30 and 31+ m distance. The TE for plyometric training was −0.01 per training session, with a maximum value of −0.02 for the 31+ m distance.

Combined Sprint Training

Several investigations used a combination of specific and nonspecific training, which have been categorized as combined sprint training in this review. Eleven studies were included in this section. The training consisted of 4–10 weeks of strength and power (29), assisted and resisted sprint training (61), strength and plyometric training (40,60,82,85,92), different strength and resistance training (43), sprint plus resistance training (89) and resisted sprinting (94), or sprint plus endurance or power training (47). The subjects (n = 211) in the included studies had an average age of 22.2 ± 2.41 years, height of 1.81 ± 0.06 m, and body mass of 82.3 ± 9.51 kg. The data for all combined training studies are shown in Table 5. Table 6 provides a summary of the pooled and averaged ES, %change, and TE across all distances. Combined training methods showed a small effect, with an average ES of −0.51 across all distances. The largest training effects (ES = −0.59; %change = −2.81) for this training method were observed for the 0–10 m distance, although training effects seemed to diminish with distance. Training efficacy equaled approximately −0.03 to −0.04 ES across all distances.

Training Efficacy

To clearly document the TE data for each of the individual protocols, they have been included again in Figure 1. From the data displayed in Figure 1, the results indicated that specific training methods seemed to be the most efficient method across all distances, followed by the combined methods of sprint training. More specifically, resisted sprinting provided the highest TE for the 0–10 and 0–20 m distances. Free sprinting had the highest TE for the 0–30 and 31+ m distances.

Discussion

This study provided a brief review of the effects of specific, nonspecific, and combined sprint training methods and their

TE on sprint times over different distances. This information is important for the strength and conditioning coach, as coaches must attempt to use the most appropriate protocols for developing speed over specific distances (i.e., 0–10, 0–20, 0–30, and 31+ m) for their athletes. Collectively, the results from the reviewed articles demonstrated that each specific (sprint, resisted, and assisted training methods), nonspecific (strength, power, and plyometric training), and combined (mixture of specific and nonspecific protocols) training method could improve sprint performance. However, as will be discussed, there seem to be specific adaptations to the distances investigated.

With regard to the 0–10 and 0–20 m sprint distances, the largest percent changes (~4.1%) and effects (ES = −1.11) were observed for specific sprint training methods (i.e., free and resisted sprinting) (Tables 1 and 2; Figure 1). With regard to free sprint training, this modality typically forms the basis for most speed development programs (56). Indeed, previous research has documented that free sprint training can induce positive technical adaptations, such as increased step length (52,53,56) and reduced contact time (89) during acceleration. Taken together, this provides evidence as to why free sprint training is a popular method used to improve speed over 20 m in athletes.

In recent years, modalities that overload an athlete (i.e., resisted sprinting), or allow an athlete to reach supramaximal velocities (i.e., assisted sprinting), have increased in popularity (10,20,25,56). Of these 2 specific modalities, resisted sprint training is more commonly used in an attempt to improve speed over distances up to 20 m (49,56,100). Certainly, of the reviewed articles, only 1 used assisted methods (61), and speed was not measured over the acceleration period. In contrast to assisted methods, resisted sprint training has been typically used to improve the acceleration phase of sprinting (4,20,57,89). Resisted sprint training has value as it can overload an athlete within the specific movements of sprint acceleration (57), and the results from this review indicated that this method seemed to be the most efficient for improving speed over distances less than 20 m (Figure 1). Indeed, relatively greater resisted sprint training loads (>10% body weight or a weight that caused more than a 10% decrease in sprint time) can not only improve linear sprinting speed (4) but also increase horizontal force production (48). Resisted sprint training methods, in this instance sled towing, can also increase step length (56) and reduce contact time (89), which illustrates the positive influence this training method can have on sprint kinematics. The data from this brief review highlight the need for specific training to optimize early sprint speed, which likely could be linked to movement specificity. To this end, both free and resisted sprint training methods can be used.

To an extent, this study also supports the use of nonspecific methods (i.e., strength, power, and plyometric training) for improving speed over distances up to 20 m (Tables 3 and 4; Figure 1). The training effects for the nonspecific methods were, however, generally less than those of the specific methods. Nonetheless, strength and conditioning coaches should be cognizant of how these methods could still influence sprint acceleration. Force production is clearly important while accelerating (72,88), in addition to generating the necessary power for sprinting (5,36). Furthermore, several studies have indicated strong relationships between maximal strength and sprint acceleration performance (6,22,64,97), and strength training by itself can improve short sprint speed (56). This underscores the importance of strength to the initial phase of sprinting. Furthermore, although strength and power training may not have a pronounced and direct transfer of training effect to running speed in trained athletes (7,75), it can positively influence changes in muscle architecture (75) and aspects of technique, such as step length during acceleration (7).

Nevertheless, the nonspecific protocols investigated in this brief review typically form the foundation for an athlete's training program, to influence other aspects of sport-specific performance. Some examples include increases in general strength (11,17,34,50), body mass (14,33), movement velocity (21), and intermuscular coordination (26), which can ultimately benefit sports performance. Further to this, plyometrics can improve leg power (19,59,91), even if the direct influence on speed may not be as pronounced when compared to specific training methods. Athletes should incorporate multiple training modalities within their training programs (40,82,85), several of which could provide some impact on speed over short distances by enhancing strength and lower-body power. Furthermore, strength and conditioning coaches must ensure that their athletes can express their strength and power within the sprint step, and this can be encouraged by using more specific methods of training.

For the longer sprint distances (0–30 and 31+ m), which is characterized as the maximum velocity phase of sprinting for most athletes (10), specific training was again found to be more beneficial than other methods. Further to this, from the reviewed research, no studies that investigated resisted methods measured sprint performance over distances greater than 30 m. In contrast, 4 studies documented the effects of free sprint training on maximum velocity sprinting (13,23,61,81), whereas 1 study analyzed assisted sprinting (61). The benefits of free sprint training are not surprising, given the importance of an effective technique for generating a high maximum running speed (62,69). Indeed, there are specific technical characteristics that can distinguish between skill levels (12,16,87) and contribute to faster sprinting performance (16,55). For example, short ground contact times (16), smaller touchdown distances (69), higher angular velocities of the stance-limb hip joint (63), a greater step frequency (16,99), and greater extension of the hip, knee, and ankle joints of the stance limb at takeoff (38) will all contribute to a higher maximal velocity when sprinting. Unfortunately, to the investigator's knowledge, there has been no scientific research that has documented the technique adaptations to maximal velocity sprinting, which result from any of the specific training methods analyzed in this study. Although it could be surmised that, similar to acceleration, there could be increases in step length (52,53,56) and decreases in contact time (89) during maximum velocity sprinting, this must be confirmed through further analysis.

Although not as pronounced as for specific training, the results from this brief review also provided evidence for the positive effect nonspecific speed training can have on 0–30 and 31+ m sprint performance. Once again, however, even though the effect on speed may not be as great as that for specific training, the findings from this brief review do not discount the value of strength, power, and plyometric training. As previously stated, there are many other benefits for an athlete that can be attained from these training protocols (18,19,32). Furthermore, the effects of plyometric training, which places an emphasis on the development of the stretch-shortening capacities of the muscles such that improvements in a dynamic athletic action such as jumping can be achieved (92,96), could be more impactful on the maximal velocity phase of sprinting. This is because the stretch-shortening capacities of the lower-body muscles contribute more to maximal velocity sprinting than acceleration (51), and a recent meta-analysis also concluded that plyometric training can positively influence sprint performance (68). Collectively, the results from this study and those of previous research suggest that strength and conditioning coaches should use nonspecific training modes to supplement the use of specific methods, as this could potentially enhance maximal sprinting speed in athletes.

The greatest limitation of this brief review of different speed training methods on sprint performance over different distances is the grouping of subjects across a range of studies. As a result, the training status of subjects across the different investigations was likely different. Indeed, highly trained athletes will adapt differently to the same stimulus when compared to healthy, untrained participants (5). In the context of this study, however, all populations were grouped into 1 pool to increase sample size for the analysis of each sprint distance. Additionally, the specific and the nonspecific training methods each combined 3 different subcategories. For some of these categories, there was limited research for protocols (i.e., assisted sprint training) or training effects over certain distances (i.e., the effects of plyometric and power training on sprint performance over the 31+ m distance). Therefore, some of the guidelines with regard to these training methods and distances should be considered with the correct context by the reader.

Nevertheless, this review provides the strength and conditioning coach with insight into the effects of various speed training methods related to distance traveled when sprinting. The overall effects of training tended to decrease with distance. This suggests that larger improvements in speed can be made over the initial few strides of a sprint, perhaps implying that sprint acceleration may be more trainable than maximum velocity in many athletes. However, such a contention needs validation through empirical means. For all distances, specific sprint training was found to be the most beneficial in decreasing sprint times. However, nonspecific training should also be used to supplement speed development for all distances.

Practical Applications

There are several practical implications for the strength and conditioning coach that can be drawn from this brief review. To improve sprint performance, distance-specific training should be implemented. For speed over short distances (i.e., a sprint distance up to 20 m), coaches should focus on specific sprint training, especially free and resisted sprinting protocols. For example, free sprinting with a focus on technique and also resisted sprinting using a moderate load (>10% body weight or weight that cause more than 10% decrease in time) seem to elicit the greatest gains in sprint performance. This type of training adheres to principles of specificity in that the primary goal is to improve technique specific to sprinting, hence the increased likelihood of transference to running speed.

The practical applications that can be drawn from this brief review also do not discount the benefits of nonspecific training. Nonspecific speed training modalities, such as strength, power, and plyometric training, would benefit other physical performance characteristics, such as increased strength and power production, which would still influence sprinting speed. Strength and conditioning coaches can use nonspecific training methods to support specific speed training. However, if a coach wishes to improve the speed of their athletes, they must use specific sprint training to ensure optimal performance improvements for all distances.

References

1. Andrzejewski, M, Chmura, J, Pluta, B, Strzelczyk, R, and Kasprzak, A. Analysis of sprinting activities of professional soccer players. *J Strength Cond Res* 27: 2134–2140, 2013.
2. Askling, C, Karlsson, J, and Thorstensson, A. Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. *Scand J Med Sci Sports* 13: 244–250, 2003.
3. Austin, D, Gabbett, T, and Jenkins, D. The physical demands of super 14 rugby union. *J Sci Med Sport* 14: 259–263, 2011.
4. Bachero-Mena, B and Gonzalez-Badillo, JJ. Effects of resisted sprint training on acceleration with three different loads accounting for 5, 12.5, and 20% of body mass. *J Strength Cond Res* 28: 2954–2960, 2014.
5. Baker, D and Nance, S. The relation between running speed and measures of strength and power in professional rugby league players. *J Strength Cond Res* 13: 230–235, 1999.
6. Baker, D and Nance, S. The relation between strength and power in professional rugby league players. *J Strength Cond Res* 13: 224–229, 1999.
7. Barr, MJ, Sheppard, JM, Agar-Newman, DJ, and Newton, RU. Transfer effect of strength and power training to the sprinting kinematics of international rugby players. *J Strength Cond Res* 28: 2585–2596, 2014.
8. Barros, RM, Misuta, MS, Menezes, RP, Figueroa, PJ, Moura, FA, Cunha, SA, et al. Analysis of the distances covered by first division Brazilian soccer players obtained with an automatic tracking method. *J Sports Sci Med* 6: 233–242, 2007.

9. Blazevich, AJ and Jenkins, DG. Effect of the movement speed of resistance training exercises on sprint and strength performance in concurrently training elite junior sprinters. *J Sports Sci* 20: 981–990, 2002.
10. Bret, C, Rahmani, A, Dufour, AB, Messonnier, L, and Lacour, JR. Leg strength and stiffness as ability factors in 100 m sprint running. *J Sports Med Phys Fitness* 42: 274–281, 2002.
11. Bruhn, S, Kullmann, N, and Gollhofer, A. The effects of a sensorimotor training and a strength training on postural stabilisation, maximum isometric contraction and jump performance. *Int J Sports Med* 25: 56–60, 2004.
12. Bushnell, T and Hunter, I. Differences in technique between sprinters and distance runners at equal and maximal speeds. *Sports Biomech* 6: 261–268, 2007.
13. Callister, R, Shealy, MJ, Fleck, SJ, and Dudley, GA. Performance adaptations to sprint endurance and both modes of training. *J Appl Sport Sci Res* 2: 46–51, 1988.
14. Candow, DG and Burke, DG. Effect of short-term equal-volume resistance training with different workout frequency on muscle mass and strength in untrained men and women. *J Strength Cond Res* 21: 204–207, 2007.
15. Chelly, MS, Ghenem, MA, Abid, K, Hermassi, S, Tabka, Z, and Shephard, RJ. Effects of in-season short-term plyometric training program on leg power, jump- and sprint performance of soccer players. *J Strength Cond Res* 24: 2670–2676, 2010.
16. Coh, M, Milanovic, D, and Kampmiller, T. Morphologic and kinematic characteristics of elite sprinters. *Coll Antropol* 25: 605–610, 2001.
17. Cormie, P, McGuigan, MR, and Newton, RU. Adaptations in athletic performance after ballistic power versus strength training. *Med Sci Sports Exerc* 42: 1582–1598, 2010.
18. Coutts, AJ, Murphy, AJ, and Dascombe, BJ. Effect of direct supervision of a strength coach on measures of muscular strength and power in young rugby league players. *J Strength Cond Res* 18: 316–323, 2004.
19. Cronin, J and Crewther, B. Training volume and strength and power development. *J Sci Med Sports* 7: 144–155, 2004.
20. Cronin, J, Hansen, K, Kawamori, N, and McNair, P. Effects of weighted vests and sled towing on sprint kinematics. *Sports Biomech* 7: 160–172, 2008.
21. Cronin, J, McNair, PJ, and Marshall, RN. Velocity specificity, combination training and sport specific tasks. *J Sci Med Sport* 4: 168–178, 2001.
22. Cronin, JB and Hansen, KT. Strength and power predictors of sports speed. *J Strength Cond Res* 19: 349–357, 2005.
23. Dawson, B, Fitzsimons, M, Green, S, Goodman, C, Carey, M, and Cole, K. Changes in performance, muscle metabolites, enzymes and fibre types after short sprint training. *Eur J Appl Physiol* 78: 163–169, 1998.
24. Deane, RS, Chow, JW, Tillman, MD, and Fournier, KA. Effects of hip flexor training on sprint, shuttle run, and vertical jump performance. *J Strength Cond Res* 19: 615–621, 2005.
25. Dhamija, JK, Singh, JS, and Gautam, R. Effects of three weeks plyometrics on sprint velocity. *Indian J Physio Occ Ther Lett* 6: 98–100, 2012.
26. Di Salvo, V, Baron, R, Gonzalez-Haro, C, Gormasz, C, Pigozzi, F, and Bachl, N. Sprinting analysis of elite soccer players during European Champions League and UEFA cup matches. *J Sports Sci* 28: 1489–1494, 2010.
27. Duthie, GM, Pyne, DB, Marsh, DJ, and Hooper, SL. Sprint patterns in rugby union players during competition. *J Strength Cond Res* 20: 208–214, 2006.
28. Faude, O, Koch, T, and Meyer, T. Straight sprinting is the most frequent action in goal situations in professional football. *J Sports Sci* 30: 625–631, 2012.
29. Faude, O, Roth, R, Di Giovine, D, Zahner, L, and Donath, L. Combined strength and power training in high-level amateur football during the competitive season: A randomised-controlled trial. *J Sports Sci* 31: 1460–1467, 2013.
30. Gabbett, TJ. Sprinting patterns of National Rugby League competition. *J Strength Cond Res* 26: 121–130, 2012.
31. Gomez, JH, Marquina, V, and Gomez, RW. On the performance of Usain Bold in the 100 metre sprint. *Eur J Phys* 34: 1227, 2013.
32. Gonzalez-Badillo, JJ, Gorostiaga, EM, Arellano, R, and Izquierdo, M. Moderate resistance training volume produces more favorable strength gains than high or low volumes during a short-term training cycle. *J Strength Cond Res* 19: 689–697, 2005.
33. Goto, K, Nagasawa, M, Yanagisawa, O, Kizuka, T, Ishii, N, and Takamatsu, K. Muscular adaptations to combinations of high- and low-intensity resistance exercises. *J Strength Cond Res* 18: 730–737, 2004.
34. Hakkinen, K, Alen, M, Kraemer, WJ, Gorostiaga, E, Izquierdo, M, Rusko, H, et al. Neuromuscular adaptations during concurrent strength and endurance training versus strength training. *Eur J Appl Physiol* 89: 42–52, 2003.
35. Harris, GR, Stone, MH, O'Bryant, HS, Proulx, CM, and Johnson, RL. Short-term performance effects of high power high force or combined weight training methods. *J Strength Cond Res* 14: 14–20, 2000.
36. Harris, NK, Cronin, JB, Hopkins, WG, and Hansen, KT. Relationship between sprint times and the strength/power outputs of a machine squat jump. *J Strength Cond Res* 22: 691–698, 2008.
37. Harris, NK, Cronin, JB, Hopkins, WG, and Hansen, KT. Squat jump training at maximal power loads vs. heavy loads: Effect on sprint ability. *J Strength Cond Res* 22: 1742–1749, 2008.
38. Hay, JG. *The Biomechanics of Sports Techniques*. Vol. 4th. London, United Kingdom: Prentice Hall International, 1994.
39. Helgerud, J, Rodas, G, Kemi, OJ, and Hoff, J. Strength and endurance in elite football players. *Int J Sports Med* 32: 677–682, 2011.
40. Herrero, AJ, Martin, J, Martin, T, Abadia, O, Fernandez, B, and Garcia-Lopez, D. Short-term effect of plyometrics and strength training with and without superimposed electrical stimulation on muscle strength and anaerobic performance: A randomized controlled trial. Part II. *J Strength Cond Res* 24: 1616–1622, 2010.
41. Hoffman, JR, Cooper, J, Wendell, M, and Kang, J. Comparison of olympic vs. traditional power lifting training programs in football players. *J Strength Cond Res* 18: 129–315, 2004.
42. Hoffman, JR, Fry, AC, Howard, R, Maresh, CM, and Kraemer, WJ. Strength, speed and endurance changes during the course of a division I basketball season. *J Appl Sport Sci Res* 5: 144.149, 1991.
43. Hoffman, JR, Ratamess, NA, Cooper, JJ, Kang, J, Chilakos, A, and Faigenbaum, AD. Comparison of loaded and unloaded jump squat training on strength/power performance in college football players. *J Strength Cond Res* 19: 810–815, 2005.
44. Hopkins, WG. *A New View of Statistics*, 2009. Available at: http://sportsci.org/resource/stats/effectmag.html. Accessed March 17, 2011.
45. Impellizzeri, FM, Rampinini, E, Castagna, C, Martino, F, Fiorini, S, and Wisloff, U. Effect of plyometric training on sand versus grass on muscle soreness and jumping and sprinting ability in soccer players. *Br J Sports Med* 42: 42–46, 2008.
46. Ingebrigtsen, J, Dalen, T, Hjelde, GH, Drust, B, and Wisloff, U. Acceleration and sprint profiles of a professional elite football team in match play. *Eur J Sport Sci* 15: 101–110, 2014.
47. Kamandulis, S, Skurvydas, A, Brazaitis, M, Stanislovaitis, A, Duchateau, J, and Stanislovaitiene, J. Effect of a periodized power training program on the functional performances and contractile properties of the quadriceps in sprinters. *Res Q Exerc Sport* 83: 540–545, 2012.
48. Kawamori, N, Newton, R, and Nosaka, K. Effects of weighted sled towing on ground reaction force during the acceleration phase of sprint running. *J Sports Sci* 32: 1139–1145, 2014.

49. Kawamori, N, Newton, RU, Hori, N, and Nosaka, K. Effects of weighted sled towing with heavy versus light load on sprint acceleration ability. *J Strength Cond Res*, 2013.
50. Kim, E, Dear, A, Ferguson, SL, Seo, D, and Bemben, MG. Effects of 4 weeks of traditional resistance training vs. superslow strength training on early phase adaptations in strength, flexibility, and aerobic capacity in college-aged women. *J Strength Cond Res* 25: 3006–3013, 2011.
51. Kraemer, WJ, Ratamess, NA, Volek, JS, Mazzetti, SA, and Gómez, AL. The effect of the meridian shoe on vertical jump and sprint performances following short-term combined plyometric/sprint and resistance training. *J Strength Cond Res* 14: 228–238, 2000.
52. Kristensen, GO, van den Tillaar, R, and Ettema, GJ. Velocity specificity in early-phase sprint training. *J Strength Cond Res* 20: 833–837, 2006.
53. Lockie, RG, Murphy, AJ, Callaghan, SJ, and Jeffriess, MD. Effects of sprint and plyometrics training on field sport acceleration technique. *J Strength Cond Res* 28: 1790–1801, 2014.
54. Lockie, RG, Murphy, AJ, Knight, TJ, and Janse de Jonge, XA. Factors that differentiate acceleration ability in field sport athletes. *J Strength Cond Res* 25: 2704–2714, 2011.
55. Lockie, RG, Murphy, AJ, Schultz, AB, Jeffriess, MD, and Callaghan, SJ. Influence of sprint acceleration stance kinetics on velocity and step kinematics in field sport athletes. *J Strength Cond Res* 27: 2494–2503, 2013.
56. Lockie, RG, Murphy, AJ, Schultz, AB, Knight, TJ, and Janse de Jonge, XA. The effects of different speed training protocols on sprint acceleration kinematics and muscle strength and power in field sport athletes. *J Strength Cond Res* 26: 1539–1550, 2012.
57. Lockie, RG, Murphy, AJ, and Spinks, CD. Effects of resisted sled towing on sprint kinematics in field-sport athletes. *J Strength Cond Res* 17: 760–767, 2003.
58. Los Arcos, A, Yanci, J, Mendiguchia, J, Salinero, JJ, Brughelli, M, and Castagna, C. Short-term training effects of vertically and horizontally oriented exercises on neuromuscular performance in professional soccer players. *Int J Sports Physiol Perform* 9: 480–488, 2014.
59. Luebbers, PE, Potteiger, JA, Hulver, MW, Thyfault, JP, Carper, MJ, and Lockwood, RH. Effects of plyometric training and recovery on vertical jump performance and anaerobic power. *J Strength Cond Res* 17: 704–709, 2003.
60. Lyttle, AD, Wilson, GJ, and Ostrowski, KJ. Enhancing performance: Maximal power versus combined weights and plyometrics training. *J Strength Cond Res* 10: 173–179, 1996.
61. Majdell, R and Alexander, MJ. The effect of overspeed training on kinematic variables in sprinting. *J Hum Mov Stud* 21: 19–39, 1991.
62. Mann, R and Sprague, P. A kinetic analysis of the ground leg during sprint running. *Res Q Exerc Sport* 51: 334–348, 1980.
63. Mann, R and Sprague, P. Kinetics of sprinting. *Track Field Q Rev* 83: 4–9, 1983.
64. McBride, JM, Blow, D, Kirby, TJ, Haines, TL, Dayne, AM, and Triplett, NT. Relationship between maximal squat strength and five, ten, and forty yard sprint times. *J Strength Cond Res* 23: 1633–1636, 2009.
65. McBride, JM, Triplett-McBride, T, Davie, A, and Newton, RU. The effect of heavy- vs. light-load jump squats on the development of strength, power, and speed. *J Strength Cond Res* 16: 75–82, 2002.
66. McEvoy, KP and Newton, RU. Baseball throwing speed and base running speed: The effects of ballistic resistance training. *J Strength Cond Res* 12: 216–221, 1998.
67. McMaster, DT, Gill, N, Cronin, J, and McGuigan, M. The development, retention and decay rates of strength and power in elite rugby union, rugby league and American football: A systematic review. *Sports Med* 43: 367–384, 2013.
68. McMaster, DT, Gill, N, McGuigan, M, and Cronin, J. Effects of complex strength and ballistic training on maximum strength, sprint ability and force-velocity-power profile of semi-professional rugby union players. *J Aust Strength Cond* 22: 17–30, 2014.
69. Mero, A, Komi, PV, and Gregor, RJ. Biomechanics of sprint running. *Sports Med* 13: 376–392, 1992.
70. Mohr, M, Krustrup, P, and Bangsbo, J. Match performance of high-standard soccer players with special reference to development of fatigue. *J Sports Sci* 21: 519–528, 2003.
71. Moir, G, Sanders, R, Button, C, and Glaister, M. The effect of periodized resistance training on accelerative sprint performance. *Sports Biomech* 6: 285–300, 2007.
72. Morin, JB, Bourdin, M, Edouard, P, Peyrot, N, Samozino, P, and Lacour, JR. Mechanical determinants of 100-m sprint running performance. *Eur J Appl Physiol* 112: 3921–3930, 2012.
73. Murphy, AJ and Wilson, GJ. The ability of tests of muscular function to reflect training-induced changes in performance. *J Sports Sci* 15: 191–200, 1997.
74. Nakamura, D, Suzuki, T, Yasumatsu, M, and Akimoto, T. Moderate running and plyometric training during off-season did not show a significant difference on soccer-related high-intensity performances compared with no-training controls. *J Strength Cond Res* 26: 3392–3397, 2012.
75. Nimphius, S, McGuigan, MR, and Newton, RU. Changes in muscle architecture and performance during a competitive season in female softball players. *J Strength Cond Res* 26: 2655–2666, 2012.
76. Petersen, C, Portus, DB, and Dawson, MR. Quantifying positional movement patterns in Twenty-20 cricket. *Int J Perform Anal Sport* 9: 165–170, 2009.
77. Rampinini, E, Coutts, AJ, Castagna, C, Sassi, R, and Impellizzeri, FM. Variation in top level soccer match performance. *Int J Sports Med* 28: 1018–1024, 2007.
78. Reilly, T. Motion analysis of workrate in different positional roles in professional football match-play. *J Hum Mov Stud* 2: 87–97, 1976.
79. Reyment, CM, Bones, ME, Lundquist, JC, Dallak, LC, and Janot, JM. Effects of a four weeks plyometric training program on measurement of power in male collegiate hockey players. *Med Sci Sports Exerc* 39: 210, 2007.
80. Rienzi, E, Drust, B, Reilly, T, Carter, JE, and Martin, A. Investigation of anthropometric and work-rate profiles of elite South American international soccer players. *J Sports Med Phys Fitness* 40: 162–169, 2000.
81. Rimmer, E and Sleivert, G. Effects of a plyometrics intervention program on sprint performance. *J Strength Cond Res* 14: 295–301, 2000.
82. Ronnestad, BR, Kvamme, NH, Sunde, A, and Raastad, T. Short-term effects of strength and plyometric training on sprint and jump performance in professional soccer players. *J Strength Cond Res* 22: 773–780, 2008.
83. Rumpf, MC, Cronin, JB, Oliver, JL, and Hughes, M. Effect of different training methods on running sprint times in male youth. *Pediatr Exerc Sci* 24: 170–186, 2012.
84. Rumpf, MC, Cronin, JB, and Schneider, C. Effect of different training methods on sprint times in recreational and athletic males. *J Aust Strength Cond* 22: 62–73, 2014.
85. Saez de Villarreal, E, Requena, B, Izquierdo, M, and Gonzalez-Badillo, JJ. Enhancing sprint and strength performance: Combined versus maximal power, traditional heavy-resistance and plyometric training. *J Sci Med Sports* 16: 146–150, 2013.
86. Salonikidis, K and Zafeiridis, A. The effects of plyometric, tennis-drills, and combined training on reaction, lateral and linear speed, power, and strength in novice tennis players. *J Strength Cond Res* 22: 182–191, 2008.
87. Slawinski, J, Bonnefoy, A, Leveque, JM, Ontanon, G, Riquet, A, Dumas, R, et al. Kinematic and kinetic comparisons of elite and well-trained sprinters during sprint start. *J Strength Cond Res* 24: 896–905, 2010.

88. Sleivert, G and Taingahue, M. The relationship between maximal jump-squat power and sprint acceleration in athletes. *Eur J Appl Physiol* 91: 46–52, 2004.

89. Spinks, CD, Murphy, AJ, Spinks, WL, and Lockie, RG. The effects of resisted sprint training on acceleration performance and kinematics in soccer, rugby union and Australian football players. *J Strength Cond Res* 21: 77–85, 2007.

90. Stølen, T, Chamari, K, Castagna, C, and Wisloff, U. Physiology of soccer: An update. *Sports Med* 35: 501–536, 2005.

91. Thomas, K, French, D, and Hayes, PR. The effect of two plyometric training techniques on muscular power and agility in youth soccer players. *J Strength Cond Res* 23: 332–335, 2009.

92. Tricoli, V, Lamas, L, Carnevale, R, and Ugrinowitsch, C. Short-term effects on lower-body functional power development: Weightlifting vs. vertical jump training programs. *J Strength Cond Res* 19: 433–437, 2005.

93. Vescovi, JD. Sprint speed characteristics of high-level American female soccer players: Female Athletes in Motion (FAiM) study. *J Sci Med Sports* 15: 474–478, 2012.

94. West, DJ, Cunningham, DJ, Bracken, RM, Bevan, HR, Crewther, BT, Cook, CJ, et al. Effects of resisted sprint training on acceleration in professional rugby union players. *J Strength Cond Res* 27: 1014–1018, 2013.

95. Wilson, GJ, Murphy, AJ, and Walshe, A. The specificity of strength training: The effect of posture. *Eur J Appl Physiol* 73: 346–352, 1996.

96. Wilson, GJ, Newton, RU, Murphy, AJ, and Humphries, BJ. The optimal training load for the development of dynamic athletic performance. *Med Sci Sports Exerc* 25: 1279–1286, 1993.

97. Wisløff, U, Castagna, C, Helgerud, J, Jones, R, and Hoff, J. Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *Br J Sports Med* 38: 285–288, 2004.

98. Young, W, Russel, A, Burge, P, Clarke, A, Cormack, S, and Stewart, G. The use of sprint tests for assessment of speed qualities of elite Australian rules footballers. *Int J Sports Physiol Perform* 3: 199–206, 2008.

99. Young, WB, Benton, D, Duthie, G, and Pryor, J. Resistance training for short sprints and maximum-speed sprints. *Natl Strength Cond Assoc J* 23: 7–13, 2001.

100. Zafeiridis, A, Saraslanidis, P, Manou, V, Ioakimidis, P, Dipla, K, and Kellis, S. The effect of resisted sled-pulling sprint start training on acceleration and maximum speed performance. *J Sports Med Phys Fitness* 45: 284–290, 2005.