

Review

The Effectiveness of Different Training Methods in Soccer for Repeated Sprint Ability: A Brief Review

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Abstract: The purpose of this study was to systematically review the literature on the effect of exercise programs on the Repeated Sprint Ability (RSA) performance of soccer players. PubMed, Scopus and Google Scholar databases were searched for original research articles. The inclusion criteria for a study were to include different groups of intervention in soccer players and present the protocol's characteristics and the study's results. Twenty-one (21) studies met the criteria. For each study, the effect size (ES) and 95% confidential interval (CI) were calculated and evaluated as trivial, small, moderate or large. The results showed that in adults, the various programs showed from trivial (e.g., ES 0.185; 95% CI \pm 0.089) to large beneficial effects (ES 2.92; 95% CI \pm 0.29). At developmental ages, the beneficial effect was from trivial to moderate (ES 0.163; 95% CI \pm 0.174, ES 0.787; 95% CI \pm 0.074). Concerning the interventional programs, studies carried out by sprint and Small-Sided Games (SSG) interventions presented a large ES, while studies that carried out RSA exercises presented moderate ES. A variety of stimuli can improve the RSA performance of soccer players by causing trivial-to-large improvements. However, more effective are interventional exercises that include stimuli related to repeated sprint ability.

Keywords: RSA; football; strength; sprint; sport performance



Citation: Michailidis, Y. The Effectiveness of Different Training Methods in Soccer for Repeated Sprint Ability: A Brief Review. *Appl. Sci.* **2022**, *12*, 11803. <https://doi.org/10.3390/app122211803>

Academic Editors: Marcin Maciejczyk and Przemysław Bujas

Received: 5 November 2022

Accepted: 18 November 2022

Published: 20 November 2022

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1. Introduction

Soccer is an intermittent sport where low and high-intensity actions occur [1,2]. In a high-level soccer match, players cover 9 to 12 km [3–5] by walking or running at different speeds. The distance covered by high-intensity running is crucial to the performance of players and constitutes 8 to 12% of the total [3,6]. Previous studies have indicated that the number of sprints of soccer players are between 17 and 81 in each match [6,7]. Their average duration is 2 to 4 s, while most of them (>90%) are less than 20 m [6,7].

The ability to perform repeated sprints (RSA) with short intervals in-between is crucial for soccer performance [8,9]. It has been reported that this ability varies considerably between professional and amateur soccer players [10,11].

Previous studies have shown that oxygen uptake, hydrogen ions management and muscle glycogen concentration [10,12–17] may affect RSA. Moreover, short RSA improvement programs affect the activity of the enzymes of the aerobic and anaerobic energy-production mechanism [18]. More specifically, for the anaerobic mechanism, the activity of enzymes such as phosphofructokinase and myokinase [19] is improved, which can lead to increased energy production through anaerobic processes and thus improve the performance for repeated sprints.

The fact that aerobic and anaerobic mechanism factors can affect the RSA [20] results in training programs being varied and different from each other (e.g., distances, breaks, repetitions) without knowing which of them are most effective. To this end, it would be beneficial for coaches to have a summary of their training methods and effectiveness in the ability of the RSA. However, we hypothesize that training methods that have similar characteristics to tests measuring RSA will be more effective.

This study aimed to investigate and summarize the existing literature on the effects of different training methods/protocols on the ability of RSA in soccer. In this review, the studies were categorized following the age of participants and into those that included appropriate training methods (e.g., sprints) and those using nonrelevant training methods (e.g., plyometrics, strength training).

2. Materials and Methods

The key issue was expressed in questions according to the Population, Intervention, Control, Outcome (PICO) design approach [21]. Articles for the review were collected after checking the bibliographical bases PubMed, Google Scholar and Scopus in early February 2021. Inclusion criteria: (a) include intervention program, (b) compare with different groups of intervention, (c) present the characteristics of the protocol, (d) present the results of the study, (e) participation of soccer players, (f) present the mean values of the groups and/or effect size, (g) published up to and including February 2021 and (h) published in English in a peer-reviewed journal.

Studies that used any kind of RSA tests were included in the review. Only the data for repeated-sprint mean (mean time of each sprint) were extracted and meta-analysed, as this is the most reliable measure of those reported concerning repeated-sprint ability [11,22].

3. Data Acquisition and Analysis

Studies were divided by age and intervention program. More specifically, in terms of age, they were divided into studies on adults and youths. The training program was divided into those that included sprints and those that did not include sprints (strength, plyometrics). The characteristics recorded by each study were the author, the year, the sample size, players' level and age, the training protocols, the total number of workouts, the duration of the intervention, the number of workouts per week and the effect of the training in percentage or effect size. This review makes efforts to quantify the effects of the training protocols [23,24].

A p value of <0.05 was considered statistically significant. Cohen's d was used to calculate the effect size (ES, 95% confidence limit) of each study using the following equation [25]:

$$ES = \frac{M_{pre} - M_{post}}{S_{pre}} * [1 - (3/(4n - 5))]$$

where M_{pre} is the mean value before the intervention, M_{post} is the mean value after the intervention, n is the sample size of the group and S_{pre} is the standard deviation (SD) preintervention. Threshold values for Cohen's ES statistics were <0.2 (trivial), >0.2 (small), >0.6 (moderate) and >1.2 (large) [26]. For each study, the percentage change after the intervention was calculated. After checking the literature, 21 studies met the criteria (Figure 1). The analysis included 530 participants with an average age of 16.5 ± 2.8 years.

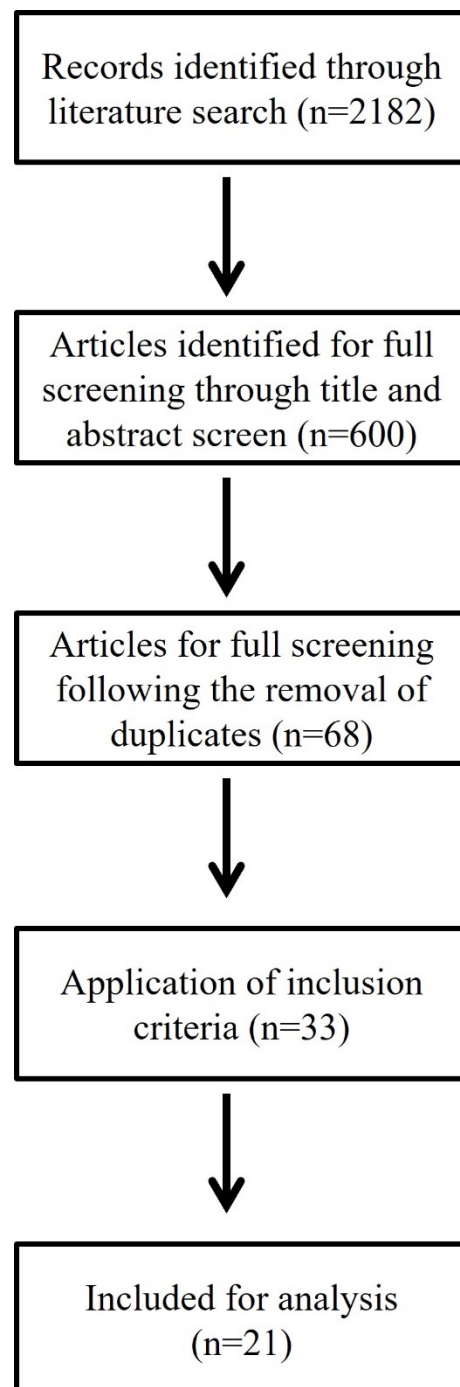


Figure 1. Study selection process.

4. Results

4.1. Age

According to the age-based separation from the 21 studies, 6 [27–32] were performed in adults (>18 years old) and 15 in youth soccer players (<18 years old). Adult studies ranged from 3 to 8 weeks, and the total training units from 9 to 24. The level of participants was from amateurs to elite. Intervention protocols included RSA exercises, resisted sprint, speed endurance, strength training, plyometrics and small-sided games (SSG). Some studies presented no effect on the performance in the RSA [28], while others showed an improvement of up to ~9% [32]. The beneficial effect ranged from trivial to moderate. Detailed results of each study are presented in Table 1.

Table 1. Characteristics and results of the studies in accordance with intervention program and age.

Study	Type of Exercise	Sample Size	Age	Level	Weeks of Training	Frequency/Week	Total Trainings	Pre	SD	Post	SD	Percent Change	Qualitative Inference
					Specific—with sprint exercises								
Borges et al., 2016 [33]	Resisted sprint	9	16.6 ± 0.6		7	2	14	7.70	±0.14	7.57	±0.15	−1.69	Moderate
	Plyometric	11			7	2	14	7.55	±0.22	7.51	±0.31	−0.53	Trivial
	RSA	7			10	1	10	6.18	±0.2	6.00	±0.15	−2.91	Moderate
Buchheit et al., 2010 [34]	RSA	7	14.5 ± 0.5	El.	10	1	10	6.35	±0.2	6.18	±0.14	−2.68	Moderate
	Explosive strength	8			10	1	10	6.09	±0.25	6.08	±0.18	−0.16	Trivial
	Explosive strength	8			10	1	10	6.28	±0.22	6.23	±0.20	−0.8	Small
Bujalance-Moreno et al., 2018 [27]	SSG	12	20.9 ± 4.5	Rec	6	2	12					−3.35	Moderate
	Control	11			6	2	12					−1.33	Small
Campos-Vasquez et al., 2015 [28]	Strength	10	18.1 ± 0.8		8	2	16	7.40	±0.18	7.36	±0.14	−0.54	Small
	Strength–COD–sled towing	11			8	2	16	7.42	±0.15	7.39	±0.16	−0.40	Trivial
	Plyometric	10			6	1	6	6.51	±0.28	6.46	±0.28	−0.77	Trivial
Chtara et al., 2017 [35]	Agility	10	13.6 ± 0.3	El.	6	1	6	6.53	±0.26	6.47	±0.25	−0.92	Small
	RSA	12			6	1	6	6.53	±0.13	6.42	±0.14	−1.68	Moderate
	Control	10			6	1	6	6.56	±0.22	6.57	±0.23	0.15	Trivial
	Game-profile-based	10			8	2	16	5.48	±0.17	5.24	±0.12	−4.38	Large
Dello Iacono et al., 2019 [29]	SSG	10	18.6 ± 0.6	El.	8	2	16	5.48	±0.14	5.23	±0.10	−4.56	Large
	RSA	9			6	2	12	7.13	±0.17	7.13	±0.21	0	N.D.
Eniseler et al., 2017 [36]	SSG	10	16.9 ± 1.1	El.	6	2	12	7.12	±0.17	7.22	±0.20	1.40	Small
Ferrari Bravo et al., 2008 [37]	RSA	21	20.8 ± 3.0	El./Am	7	2	14	7.53	±0.21	7.37	±0.17	−2.12	Moderate
	HI aerobic interval	21				2	14	7.42	±0.22	7.40	±0.22	−0.27	Trivial
Hill-Haas et al., 2009 [38]	Generic training	9	14.6 ± 0.9	El.	7	2	14	42.2	±1.8	42.3	±1.5	0.24	Trivial
	SSG	10			7	2	14	42.1	±1.1	42.0	±1.4	−0.24	Trivial
Iaia et al., 2015 [39]	Speed end. Passive rec	6	18.5 ± 1.0	Prof	3	3	9	86.09	±6.3	83.97	±4.72	−2.46	Small
	Speed end. Active rec	7			3	3	9	83.81	±2.37	84.65	±2.27	1.00	Small
Iaia et al., 2017 [30]	RSA 15 s rest	10	17.0 ± 1.0	Subel.	5	2	8	92.91	±4.66	90.47	±4.24	−2.63	Small
	RSA 30 s rest	10			5	2	8	91.45	±4.35	88.22	±4.65	−3.53	Moderate
Ingebrigtsen et al., 2013 [40]	Anaerobic speed endurance	8	16.9 ± 0.6	El.	6	2	12	5.49	±0.15	5.44	±0.17	−0.91	Small
	Control11	8			6	2	12	5.85	±0.3	5.49	±0.29	−6.15	Moderate
	Plyometric	13			8	2	16	48.8	±2.2	47.8	±2.5	−2.05	Small
Negra et al., 2020 [41]	Control	11	12.7 ± 0.2	El.	8	2	16	51.5	±1.4	52.2	±1.6	1.36	Small
	Speed end. Active rec	7		Prof	3	3	9	83.81	±2.37	84.65	±2.27	1.00	Small
Rey et al., 2017 [32]	Resisted sprint	10	23.7 ± 4.5	Am.	6	2	12	19.77	±0.46	18.30	±0.74	−7.44	Large
	Unresisted sprint	9			6	2	12	19.53	±0.95	17.71	±0.64	−9.32	Large
	RSA 1 d/w	13			6	1	6	4.2	±0.17	4.12	±0.20	−1.90	Small
Rey et al., 2019 [31]	RSA 2 d/w	14	12.3 ± 0.5		6	2	12	4.2	±0.20	4.08	±0.19	−2.86	Small
Spinetti et al., 2018 [42]	Strength complex contrast	10	18.4 ± 0.4	El.	8	3	24	7.43	0.10±	7.33	±0.12	−1.35	Moderate
	Strength	12			8	3	24	7.54	±0.23	7.47	±0.24±	−0.93	Small
	RSA	10			10	1	10	5.42	±0.18	5.30	±0.14	−2.21	Moderate
Tonnessen et al., 2011 [43]	Control	10	16.4 ± 0.9	El.	10	1	10	5.41	±0.19	5.35	±0.18	−1.11	Small

Table 1. Cont.

Study	Type of Exercise	Sample Size	Age	Level	Weeks of Training	Frequency/Week	Total Trainings	Pre	SD	Post	SD	Percent Change	Qualitative Inference
Nonspecific—without sprint exercises													
Hammami et al., 2016 [44]	Plyometric	15	15.7 ± 0.2	El.	8	2	16	46.38	±1.36	45.10	±1.77	−2.76	Moderate
	Control	13	15.8 ± 0.2		8	2	16	45.64	±2.33	45.66	±2.29	0.04	Trivial
Hammami et al., 2017 [45]	Strength contrast	16	16.0 ± 0.5		8	2	16	7.64	±0.20	7.46	±0.13	−2.36	Moderate
	Strength	16			8	2	16	7.68	±0.13	7.60	±0.17	−1.04	Small
Hammami et al., 2018 [46]	Control	12	16.2 ± 0.6		8	2	16	7.71	±0.39	7.62	±0.40	−1.17	Small
	Strength	19			8	2	16	7.70	±0.14	7.61	±0.17	−1.17	Moderate
Negra et al., 2020 [41]	Control	12	15.8 ± 0.2		8	2	16	7.63	±0.30	7.53	±0.30	−1.31	Small
	Plyometric	13	12.7 ± 0.2		8	2	16	48.8	±2.2	47.8	±2.5	−2.05	Small
Trajkovic et al., 2020 [47]	Control	11	11.2 ± 0.8		8	2	16	51.5	±1.4	52.2	±1.6	1.36	Small
	FIFA11+	19	10.9 ± 0.8		4	3	12	60.63	±3.98	61.66	±8.2	1.70	Small
	Control	17			4	3	12	58.86	±3.40	59.29	±3.4	0.73	Trivial

Am.: Amateur; El.: Elite; Rec.: Recreational; Subel.: Subelite; Prof.: Professional; COD: Change of direction; RSA: Repeated sprint ability; SSG: Small-sided games; d/w: Days per week; End.: Endurance; Rec.: Recovery; areas with gray highlight the studies performed with adults.

The studies carried out in youth soccer players are much more ($n = 15$) with the age of the participants, ranging from 11 to 17.3 years. The interventional programs lasted from 4 to 10 weeks and the total number of workouts was from 6 to 16. As in adult studies, interventional programs varied from the RSA to SSG and plyometrics. The improvement ranged from 0 to ~6% while the ES ranged from trivial to moderate (Figure 2). Detailed results of each study are presented in Table 1.

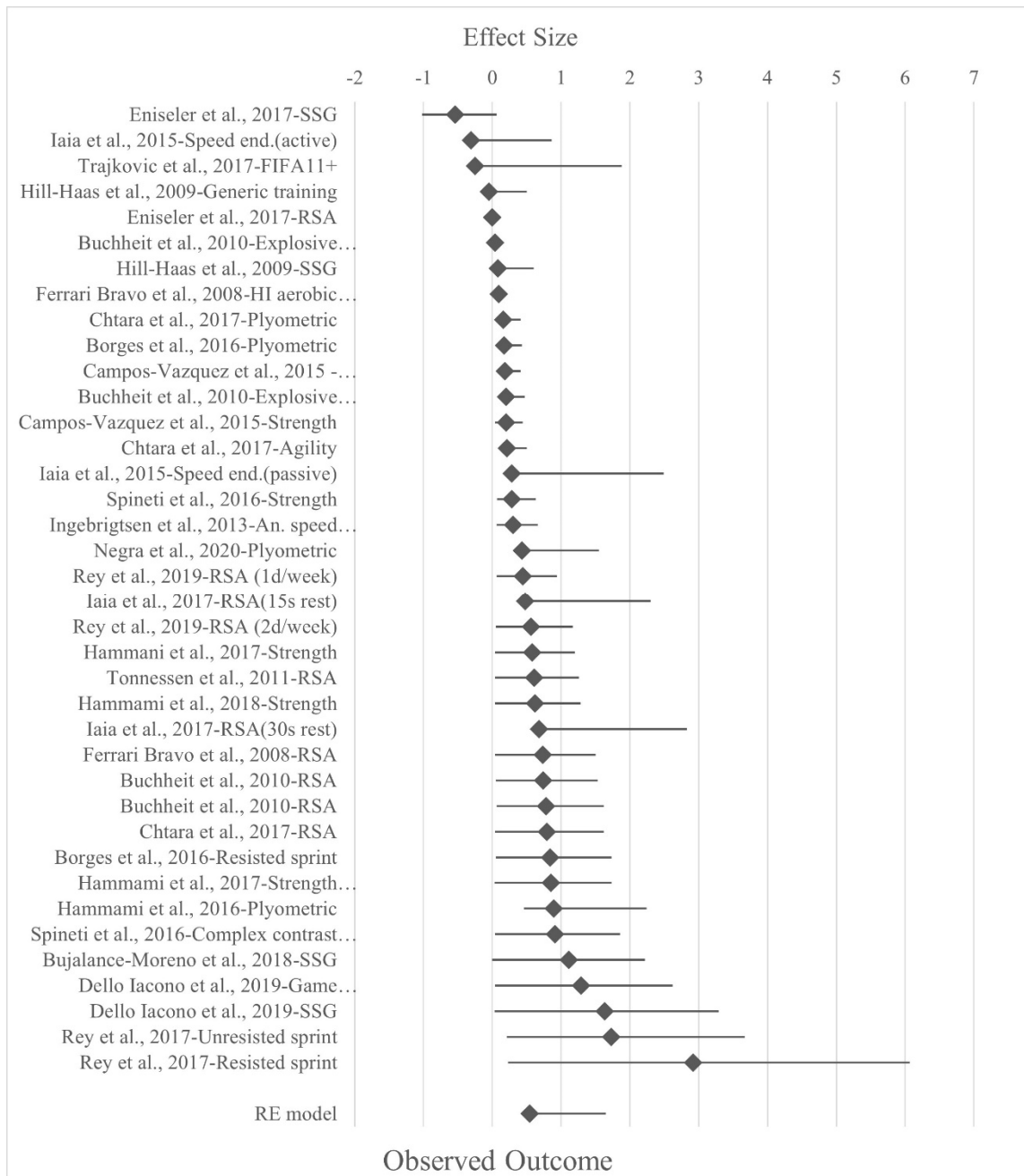


Figure 2. Effects of different training programs on RSA of soccer players.

4.2. Training Protocol

The studies were categorized into those that included protocols where repeated sprints (specific) were applied and those that did not include sprints in their interventional programs (nonspecific). In the studies that used sprinting in the training protocol, the duration ranged from 3 to 10 weeks and the total number of training units from 6 to 14. However,

many of these protocols implemented programs with a different objective from the RSA, such as generic training, anaerobic endurance training [40], speed endurance training [39], resident and no-resident sprint training [32]. The findings showed that there were studies that showed no change in RSA [28,38,40] and others with improvements of ~9% [32]. Detailed results of each study are presented in Table 1.

Studies in which the training program did not include sprint exercises were much less ($n = 5$). In these studies, the duration of the intervention was from 4 to 8 weeks and the total number of workouts was from 12 to 24. The training programs of these studies included plyometric training, maximum strength training, SSG and the FIFA11+ program. Their findings showed that there were studies where RSA ability did not change [45,46] but also studies where the RSA performance improved by 2.7%, but the differences were not significant [44]. Detailed results of each study are presented in Table 1.

5. Discussion

Soccer, as mentioned above, is an intermittent team sport where soccer players make ~1200 cyclical changes in activity every 3 to 5 s. Many of these actions are sprints [48], indicating RSA's importance in high-level soccer. In recent years, more and more studies have been investigating the effect of specific programs on this capability [28,39,46], with most of them showing improvement after the implementation of the intervention program.

As mentioned above, studies on soccer players were included in this review. Although there are several studies involving various sports, studies in soccer players are relatively limited ($n = 21$), while research work on the effects of different training programs on RSA soccer players does not exist.

The first separation of studies was made in relation to age in this study. Of the six studies carried out in adulthood, only Campos-Vasquez et al. (2015) [28] did not notice an improvement in the RSA after the implementation of their intervention, while in five studies carried out on youth soccer players, there were no improvements in the performance of the RSA [38,40,45,47]. In adult studies, performance improvement reached ~9%, while in minors it reached ~3%, although in any case, the ES ranged from trivial to large. These studies show that interventional programs cause less percentage improvement in youth soccer players. This may be related to the characteristics of the protocols (intensity, volume) chosen in each case. Moreover, this difference may be due to the characteristics of developmental ages. More specifically, the studies included in the review include participants from 11 to 17 years of age. It has been reported in previous studies that children in their preteens have reduced anaerobic capacity and their actions are more dependent on the aerobic-energy-production mechanism [49]. In this context, they show less lactic acid production and greater oxidation of fatty acids [50,51] compared to adults. In addition, the level of biological maturation seems to affect the effectiveness of training [52,53]. The above-reasons may influence the results of the studies.

Concerning interventional programs, the studies were divided into those that applied sprint exercises (specific) and those that did not include sprint exercises (nonspecific). Of the specific studies ($n = 13$), in only two were no improvement in RSA observed after the program implementation, while in nonspecific studies ($n = 8$), no improvements were observed in three studies. Compared to the two categories, the percentage of studies where no effect occurred was ~15% for the specific and ~38% for the nonspecific. This observation may be due to the training principle of the specialization of the stimulus. Two methodologies are followed to improve the RSA. In the first, based on the above-principle of coaching, exercises are applied that include repeated sprints. The second method improves the individual factors that affect the performance of the RSA such as metabolic factors [54].

Of the nonspecific studies, two used plyometric programs, three used strength programs, two used SSG and one used the FIFA11+ program. Of the two studies using plyometric exercises, Hammami et al., (2016) [44] did not notice significant changes, as opposed to Negra et al. (2020) [41]. Looking at the protocols they used, we find that Hammami et al. (2016) [44] applied high-intensity jumps, but the total volume of the program

(~700 jumps) was almost half that of Negra et al. (2020) [41] (~1300 jumps), which indicates that the volume of training can affect the effectiveness of the program, considering that the total workouts were 16 for both teams.

Of the three studies that implemented strength programs, two were conducted by the same laboratory and implemented the same program without finding significant effects on the RSA [45,46]. However, Spinetti et al. (2018) [42] noted that a complex contrast training program caused a significant improvement in the RSA performance compared to a traditional strength program. The above-differences are likely due to the different programs of Spinetti et al. (2018) [42], who had three strength training sessions for eight weeks, compared to the two of Hammami et al. [45,46]. Moreover, Spinetti et al. [42] used more than three exercises for the lower extremities (>3 in each workout) as opposed to Hammami et al. [44], who used only the half-squat exercise. As we understand, the volume of programs varies considerably. Moreover, the lack of significant differences in the RSA after the implementation of the strength program may be because the strength does not affect the important factors on which the RSA depends, such as aerobic capacity that helps in rehabilitation [55] and the increase in energy substrates (CP) necessary for repetitive sprints [56].

Studies examining SSG's effect on the RSA observed a significant improvement in it. The characteristics of the two studies differed quite a bit. More specifically, Bujalance-Moreno et al. (2018) [27] implemented a program for six weeks, 4 vs. 4 on a field, with a ratio of ~75 m²/player, while Dello Iacono et al. (2018) [29] implemented a program for eight weeks, 5 vs. 5 on a field, corresponding to 126 m²/player. The findings of these studies show that SSG can be used to improve RSA. As we can observe, they used small-player relationships of 4 vs. 4 and 5 vs. 5 and relatively large spaces of 78 m²/player and 126 m²/player.

Finally, in the studies [47] where FIFA11+ was applied, no effect on the RSA was observed. It is well-known that this program (FIFA11+) was designed to prevent injuries to soccer players and not to affect physical abilities that are important for the RSA. The stimulus was not specific to the RSA, so the effectiveness was small.

Of the thirteen specific studies, eight used an RSA program, three an anaerobic speed endurance and interval training and two studies used programs with resisted sprint. Of the studies that included RSA, only two [28,36] did not observe any changes in the RSA_{meantime}. However, the study of Eniseler et al. observed an improvement in the index of % RSA_{decrement}. In another study, Campos-Vasquez et al. (2015) [28] used an RSA or an RSA and strength combination program. The lack of significant differences were justified by the authors as the possible fatigue of the athletes, as the study was carried out at the end of the racing season. The specialization of the training stimulus was important in improving the RSA regardless of the differences between the training programs.

Of the three studies that used interval or anaerobic endurance training, only in the study of Iaia et al. (2015) [39] was there an improvement in the RSA. The difference in these studies is likely due to the participants. More specifically, all three studies implemented programs that affected the anaerobic-energy-production mechanism. Anaerobic training is known to increase the activity of anaerobic enzymes (e.g., phosphofructokinase, myokinase) [19], increases the expression of the Na⁺, K⁺ transport pump [57], increases the muscle glycogen content [19] and enhances muscle capillarization [58]. It is known that adults have better anaerobic adaptations than youths. In two studies, no differences were observed; the participants were adolescents.

Finally, in the two studies carrying out programs involving resistance sprints, significant improvements in the ability of the RSA were observed. Reports show that resistance sprints can increase muscle capacity to store elastic energy and improve power output [59–61]. This can affect players' sprint performance, as it can improve the horizontal force and rate of force development [62].

In this review, the heterogeneity of intervention programs that were used for RSA improvement is obvious. This review was intended to present the different training

programs that soccer players can use to improve the RSA. Although there are several studies on the RSA, those applied to soccer players are limited. The studies were selected to clarify which programs can be applied to soccer players to affect the RSA positively.

This review has some limitations. Firstly, a reduced number of studies were available for some interventions such as resistance sprints (i.e., two studies). Secondly, a reduced number of participants were included in most studies. Finally, male studies were used, as there does not exist any female studies.

6. Conclusions

Many kinds of exercise (SSG, explosive strength training, resisted sprint training) can improve performance in the RSA. However, the results showed that programs involving RSA exercises and resisted-sprint exercises were more effective for athletes. The training principle can explain this observation about the stimulus specification. More work is needed with larger samples and interventional programs that apply to the weekly microcycle of soccer teams to draw certain conclusions about the most effective programs.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The author declares no conflict of interest.

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