


Review

# The Effects of Different Training Interventions on Soccer Players' Sprints and Changes of Direction: A Network Meta-Analysis of Randomized Controlled Trials

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**Abstract:** Objective: To compare and rank the effects of different training interventions on the sprint and change of direction (COD) abilities of soccer players using a network meta-analysis. Methods: The PubMed, Cochrane, and Web of Science databases were searched for papers published up to June 2022. Inclusion criteria: (1) No distinction was made between nationality, region, or gender. No distinction was made between physical activity times or habits. Healthy and disease-free soccer players (age  $\geq 18$  years old) were eligible. (2) Different training methods and their combinations were used. (3) Groups of either no training or single training, or combined training were included. (4) Randomized controlled trials (RCTs) were included. (5) The outcome indicators included at least one of the following: sprint, agility, and change of direction (COD). Exclusion criteria: (1) studies in non-English were not included. (2) Individual studies, general public studies, literature review studies, qualitative studies, case studies, and studies with unclear data such as means and standard deviations were not included. (3) Studies using the same data were not included. (4) Interventions that could not be statistically analyzed because of insufficient numbers of studies were not included. RCTs that satisfied the inclusion criteria were included. Paired analyses and network meta-analyses were performed using random-effects models. The included studies were assessed using the Cochrane risk-of-bias assessment tool. The surface under the cumulative ranking curve (SUCRA) metric was used to rank the effectiveness of each treatment and identify the best treatment. Results: The network meta-analysis (NMA) included eleven RCTs with a total of two-hundred and seventy-seven participants and six interventions: plyometrics combined with sprint, agility, and resistance training (P+T+S+A), plyometrics combined with sprint and agility training (P+S+A), resisted sprinting combined with agility training (RS+A), plyometric training (P), resistance training (T), soccer skills, and a strategy training control group (C). P+T+S+A ranked highest in terms of improving soccer players' 10 m sprint performance (SUCRA = 70.2%) and COD (SUCRA = 75.0%). P+S+A ranked highest in terms of improving soccer players' 20 m sprint performance (SUCRA = 69.8%). Conclusions: Based on the network meta-analysis, for combined training, P+T+S+A was more effective at improving the sprinting and COD ability of soccer players. In the single training mode, plyometric training was the most effective. To improve sprint and COD ability, P+T+S+A should be chosen. Such improvements may be expected after P+T+S+A interventions for a duration of six or more weeks. However, gender, competitive level, and other factors will affect the assessment results. Given the limitations of the above analysis, these results should be interpreted with caution.



**Citation:** Dong, K.; Jeong, G.; Chun, B. The Effects of Different Training Interventions on Soccer Players' Sprints and Changes of Direction: A Network Meta-Analysis of Randomized Controlled Trials. *Appl. Sci.* **2023**, *13*, 446. <https://doi.org/10.3390/app13010446>

Academic Editor: Jesús García Pallarés

Received: 11 December 2022

Revised: 22 December 2022

Accepted: 27 December 2022

Published: 29 December 2022



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**Keywords:** plyometric; sprint training; strength training; combined training; agility; speed

## 1. Introduction

Soccer is the world's most popular sport and is unique, with more than 270 million participants [1,2]. Soccer players need to perform a lot of repetitive straight sprinting, direction

changing, jumping, turning, and other actions whilst playing the game [3,4]. Among them, straight sprinting is the most common action. From analyzing the movements of scoring players in soccer games, we know that straight sprinting and agility account for 51% of the total number of movements [5–7]. Compared to previous seasons, high-intensity running distance and actions have increased by 30% and 50%, respectively [8]. Sprinting and agility can be used to distinguish the level of an athlete, as has been shown in the studies in [4,9].

Soccer players' abilities such as sprinting and COD can be assessed through a variety of physical fitness tests (i.e., the 505 test and the linear speed 10 m test). These tests are inexpensive, easy to perform, and popular among coaches [10]. It should be highlighted here that agility is used to describe a "rapid whole-body movement with a change of velocity or direction in response to a stimulus", whereas COD is used to describe a pre-planned testing environment, whereby athletes change their movement direction and velocity without the inclusion of perceptual–cognitive processes [11].

To improve soccer players' performances in areas such as sprinting and agility, RCTs of different training interventions have been conducted. Good results have been obtained in strength training, plyometric training, speed–agility–quickness (SAQ) training, sled sprint training, and compound training [12–16]. In a previous systematic review and meta-analysis, the effect of strength training on the sprinting and jumping performance of professional soccer players was assessed [17]. Other studies have considered potential gender differences and different responses between men and women [8,18] and the effects of plyometric training on physical performance such as sprinting in male and female soccer players [19,20].

To find out which training method is the best, the effects of strength training and plyometric training on the sprinting, change of direction, and jumping performances of female soccer players were compared, and the effect of plyometric training was better than that of strength training [21]. When comparing the effects of sled sprint and vest-resistance sprint training on the sprint performance of young soccer players, sled sprint training was better [22]. In a comparison of the effects of weightlifting resistance training and plyometric training on players' speed abilities, the magnitude of the improvement was similar [23]. Moreover, for short sprint performance, Plisk et al. [24] divided training modes into three levels based on task specificity and primary (free sprint), secondary (resistance sprint, downhill assist sprint, etc.), and tertiary (strength or plyometric training, etc.) training. However, there was no consistent conclusion as to how to improve soccer players' sprinting and agility abilities or which training method was the best. As far as we know, there have been no network meta-analyses comparing more than two training interventions.

NMA is a relatively novel analysis method, which is different from a traditional meta-analysis. It combines the evidence of direct and indirect comparisons into a single analysis to compare the effects of two or more interventions [25]. It can be used to rank different interventions to inform the selection of an optimal training intervention [25].

Therefore, the purpose of this study was to perform a network meta-analysis to compare the effects of various training interventions using the results of previous RCTs and to derive the best interventions that relevant practitioners can refer to in selecting the most effective training. The research hypothesis was as follows: (1) combined training is more effective than single training, and (2) including more types of exercise makes training more effective.

## 2. Materials and Methods

Our research program was registered on Prospero, the international register of expectations for system evaluation, with the registration number CRD42022349079.

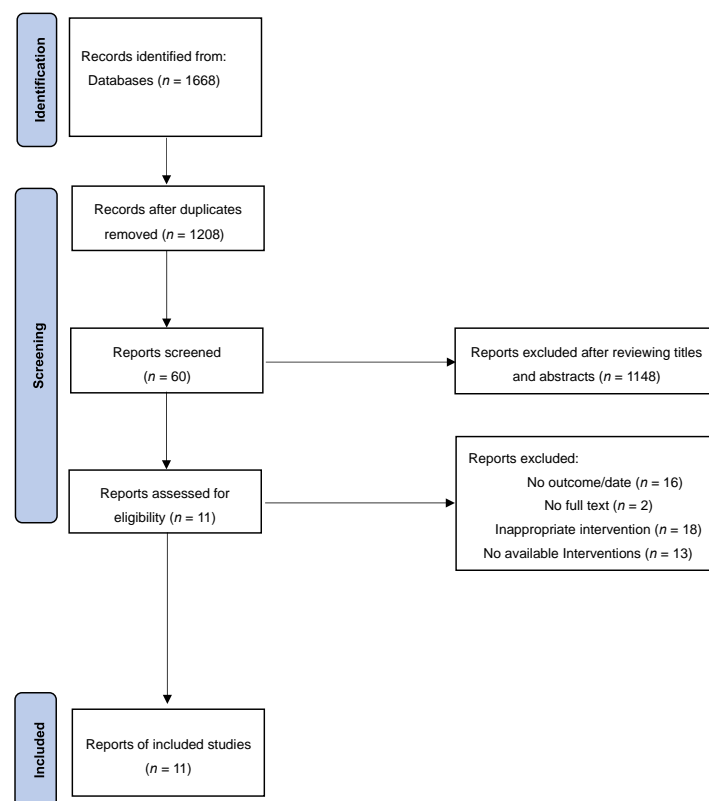
### 2.1. Search Strategy

The electronic databases searched included PubMed, Cochrane, and Web of Science from their inception to June 2022. The search strategy was constructed around the PICOS tool. (P) Subjects: healthy soccer players without disease. (I) Intervention: training. (C) Experimental group: no training or single training, or combined training. (O) Outcome

measures: sprint, agility, and COD. (S) Experimental design: randomized controlled trial. The detailed search strategy is shown in Table 1. The search process is shown in Figure 1.

**Table 1.** Search strategy on PubMed, Cochrane, and Web of Science.

|                |   |
|----------------|---|
| PubMed         | #1 Athletes OR players OR player OR athlete; #2 training OR exercise; #3 soccer OR football; #4 speed OR sprint OR velocity OR agility OR performance OR change of direction OR COD; #5 randomized controlled trials (publication type)<br>#6: #1 AND #2 AND #3 AND #4 AND #5 |
| Cochrane       | #1 Athletes OR players OR player OR athlete; #2 training OR exercise; #3 soccer OR football; #4 speed OR sprint OR velocity OR agility OR performance OR change of direction OR COD<br>#5: AND #1–#4  |
| Web of Science | #1 TS = (athletes OR players OR player OR athlete); #2 TS = (training OR exercise); #3 TS = (soccer OR football); #4 TS = (speed OR sprint OR velocity OR agility OR performance OR change of direction OR COD)<br>#5: #1 AND #2 AND #3 AND #4                                |



**Figure 1.** PRISMA flowchart for inclusion and exclusion of studies.

### 2.2. Inclusion Criteria

No distinction was made between nationality, region, or gender. No distinction was made between physical activity times or habits. Healthy and disease-free soccer players (age  $\geq 18$  years old) were eligible. (2) Different training methods and their combinations, including plyometric training, rapid stretching, compound training, etc., and in combination with each other, were used. (3) No training or single training, or combined training were used. (4) Randomized controlled trials were used. (5) The outcome indicators included at least one of the following: sprint, agility, and COD.

### 2.3. Exclusion Criteria

Studies in non-English were excluded. (2) Individual studies, general public studies, literature review studies, qualitative studies, case studies, and studies with unclear data such as means and standard deviations were excluded. (3) Studies using the same data were excluded. (4) Interventions that could not be statistically analyzed because of insufficient numbers of studies were excluded.

#### 2.4. Study Selection

Studies were screened and excluded using the management software Endnote20. Two researchers (Dong and Chun) first used the Endnote software to deduplicate the articles. Secondly, by reading the titles and abstracts of the articles, the included and excluded articles were determined. Finally, we read the full texts and made further decisions about inclusion. If there was an objection, it was discussed and resolved by a third researcher (Jeong).

#### 2.5. Data Extraction

We extracted data from original articles based on research, including (1) author; (2) sample size; (3) age; (4) publication year; (5) testing metrics; (6) training period, training frequency, and volume; (7) intervention measures; and (8) competitive level, i.e., professionals (the first division of their countries or above, Greek Super league, Champions League, Norwegian Premier League, Brazilian First Division, Moroccan First Division, Swedish First Division, Irish First Division etc.), and sub-level, i.e., semi-professionals [17].

#### 2.6. Risk of Bias of Individual Studies

The risk of bias (ROB) was assessed using the Cochrane Handbook version 5.1.0 tool for assessing the ROB in RCTs. Seven aspects were considered: (1) random sequence generation; (2) allocation concealment; (3) the blinding of participants and personnel; (4) the blinding of outcome assessments; (5) incomplete outcome data; (6) selective reporting; and (7) other biases. Based on the number of components in the experiment that may have had a high ROB, there were three levels of ROB: high risk (five or more), intermediate risk (three or four), and low risk (two or fewer) [26].

#### 2.7. Data Analysis

In studies where exercise was the intervention, all variables were continuous and were analyzed using standard mean difference (SMD) with a 95% confidence interval (CI) [27]. There were potential differences between the studies, so we chose a random-effects model for the analysis instead of a fixed-effects model [28].

We use the Stata14.1 software and, according to the PRISMA NMA instruction manual [29], a network meta-analysis was performed based on a frequentist framework. A nodal approach was used to quantify and demonstrate the agreement between indirect and direct comparisons; if  $p > 0.05$ , the agreement was verified [30]. In the resulting network graph, each node represented a different exercise intervention and a different control condition, and the lines connecting the nodes represented direct comparisons between interventions. The size of each node and the width of the connecting lines were proportional to the number of studies [31]. The exercise interventions were ranked using the surface under the cumulative ranking curve (SUCRA) value and the mean ranking (Mean Bank); the higher the SUCRA value, the better the ranking. To check for bias due to small studies, funnel plots were generated and checked visually using symmetry criteria [32].

### 3. Results

#### 3.1. Study Identification and Selection

Our literature search yielded 1668 studies, with 460 duplicates being removed automatically or manually. Reviews, theoretical research, and survey-based research were initially screened by reading the title and abstract of the literature, and 1148 items were deleted. After reading the full texts, for a variety of reasons, 11 studies were eventually included (Figure 1).

#### 3.2. Characteristics of the Included Studies

All the studies were published from the databases' inception to June 2022, with a total sample size of 277 people. Most of the participants were men, and the average age of the participants ranged from 18 to 24. The experimental group was given single or combined training, and the control group was given technical and tactical soccer training or strength

training. The number of training weeks ranged from five to twelve. The characteristics of the included studies are shown in Table 2.

**Table 2.** Characteristics of study participants.

| Study                       | Competitive Level | Type | No. of Subjects |    |    | Age (Years) | Exercise Type | Test                    | Duration, Frequency  | Exercise Interventions   |
|-----------------------------|-------------------|------|-----------------|----|----|-------------|---------------|-------------------------|--|--|
|                             |                   |      | Total           | M  | F  |             |               |                         |  |  |
| Faude et al., 2013 [33]     | Semi-professional | RCT  | 8               | 8  | 0  | 23.1 ± 2.7  | P+T+S+A       | 10 m, COD               | 7 weeks<br>2 sessions/week<br>30 min/session                       | Unilateral 4 × 90% 1RM + single-leg hurdle, jump 5 × 4 sets, rest 4 min, bilateral 50–60% 1RM, squat, sprint, etc., rest 1–2 min |
|                             |                   |      | 8               | 8  | 0  | 22.6 ± 2.4  | C             |                         |  |  |
| Rodríguez et al., 2017 [34] | Semi-professional | RCT  | 10              | —  | —  | 24.5 ± 3.4  | P+T+S+A       | 10 m, 20 m              | 6 weeks<br>2 sessions/week   | Squat 4–6 repetitions, I = 45–60% 1RM CMJ 3 sets × 5 reps, COD 3–5 × 10 s, sprint 3–4 × 20 m, rest, 3 min                        |
|                             |                   |      | 10              | —  | —  |             | C             |                         |  |  |
| Pedersen et al., 2019 [35]  | Semi-professional | RCT  | 19              | 0  | 19 | 18 ± 3      | T             | 10 m                    | 5 weeks<br>2 sessions/week   | Free-barbell squats  |
|                             |                   |      | 15              | 0  | 15 | 19 ± 2      | C             |                         |  |  |
| Ronnestad et al., 2008 [16] | Professional      | RCT  | 8               | 8  | 0  | 23 ± 2      | P+T           | 10 m                    | 7 weeks<br>2 sessions/week   | Alternate-leg bound 2–4 × 8–10, double leg hurdle jump + single leg forward hop 2 × 5, etc.                                      |
|                             |                   |      | 6               | 6  | 0  | 22 ± 2.5    | T             |                         |  |  |
| Loturco et al., 2016 [36]   | Professional      | RCT  | 9               | 9  | 0  | 18.4 ± 1.2  | P             | 10 m, 20 m, COD         | 6 weeks<br>2 sessions/week   | 6 × 8–4, rest, 2 min, jump   |
|                             |                   |      | 8               | 8  | 0  |             | T             |                         |  |  |
| Ribeiro et al., 2020 [37]   | Semi-professional | RCT  | 8               | 8  | 0  | 18.6 ± 0.52 | P             | 10 m, COD               | 7 weeks<br>2 sessions/1–5 week<br>12 sessions<br>35–45 min/session | Multi-direction hops 1–3 × 8, single-leg forward 2–3 × 8–12, box jump, drop jump 2–3 × 10–12, etc., rest, 2 min.                 |
|                             |                   |      | 8               | 8  | 0  | 18.4 ± 0.52 | T             |                         |  |  |
| Spinetti et al., 2019 [38]  | Semi-professional | RCT  | 10              | 10 | 0  | 18.4 ± 0.4  | P+T+S+A       | 10 m, 20 m, COD (93639) | 8 weeks<br>3 sessions/week<br>40 min/week                          | Plyometric hurdle hops, single-arm alternate-leg bound over barrier, diagonal jump over barrier, etc., 10 × 2, rest, 3 min.      |
|                             |                   |      | 12              | 12 | 0  |             | T             |                         |  |  |
| Ozbar et al., 2014 [39]     | Semi-professional | RCT  | 9               | 0  | 9  | 18.3 ± 2.6  | P+S+A         | 20 m                    | 8 weeks<br>1 session/week<br>60 min/session                        | Standing long jump, single-leg horizontal jump, side-to-side slide and hops, etc., 3–5 × 5–12, sprint, COD, etc.                 |
|                             |                   |      | 9               | 0  | 9  | 18.0 ± 2.0  | C             |                         |  |  |
| Shalfawi et al., 2013 [40]  | Semi-professional | RCT  | 10              | 0  | 10 | 19.4 ± 4.4  | RS+A          | 20 m                    | 10 weeks<br>1 session/week   | 6–3–9–9–6 agility, with resistance running band, repeated sprint, 4–5 × 40 m, exercise rest, 90 s, sets, rest, 10 min.           |
|                             |                   |      | 10              | 0  | 10 |             | T             |                         |  |  |
| Hwang & Jooyoung, 2019 [41] | Semi-professional | RCT  | 10              | 10 | 0  | 20.0 ± 0.6  | P+T+S+A       | COD                     | 12 weeks<br>5 sessions/week<br>20–25 min/session                   | 2 × 30 s squat, VJ, LJ, box jump, 2 × 30 s, agility running, etc.  |
|                             |                   |      | 10              | 10 | 0  | 20.1 ± 0.8  | C             |                         |  |  |
| Ramirez et al., 2016 [42]   | Semi-professional | RCT  | 19              | 0  | 19 | 22.4 ± 2.4  | P (female)    | COD (Illinois)          | 6 weeks<br>2 sessions/week<br>40 min/session                       | Jump, reverse jump, etc., 5 sets   |
|                             |                   |      | 19              | 0  | 19 | 20.5 ± 2.5  | C (female)    |                         |  |  |
|                             |                   |      | 21              | 21 | 0  | 20.4 ± 2.8  | P (male)      |                         |  |  |
|                             |                   |      | 21              | 21 | 0  | 20.8 ± 2.7  | C (male)      |                         |  |  |

C = control group; A = agility training; T = resistance training; P+T = plyometric + resistance training; P+S = plyometric + sprint training; RS = resisted sprint; P+T+S+A = plyometric + resistance training + sprint + agility training. Ex. 1 = exercise 1 (908 isometric half squat exercise); s = seconds; reps = repetitions; Ex. 2 = exercise 2 (jump from the seated position); Ex. 3 = exercise 3 (single-leg jump, alternating right and left). 1/2 Squat = the degree of knee flexion was over 90°; Skipping = maximal frequency on distance (10, 15, or 20 m); V. Jumps = vertical jumps; Stride J = stride jump; Sidelong = sidelong jumps; 28 triples = repeat the second movement of triple jump.

### 3.3. Quality Assessment of the Included Studies

The methodological quality assessments are shown in Figures 2 and 3. Eleven studies mentioned randomization. Five studies explained the specific methods related to allocation concealment. Nine studies were considered to have a high risk of performance bias. The risk of attrition bias and reporting bias was low in all eleven RCTs. Therefore, seven studies were at moderate risk of bias and four were considered to be at low risk of bias.

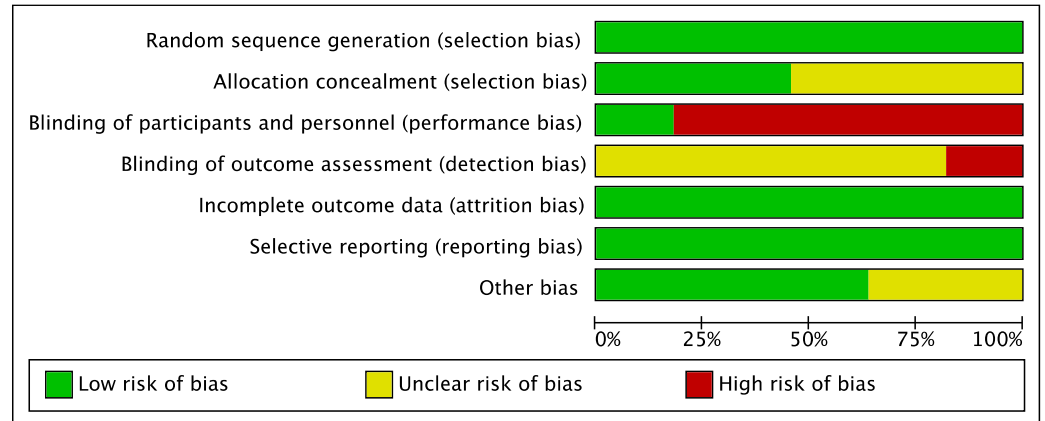


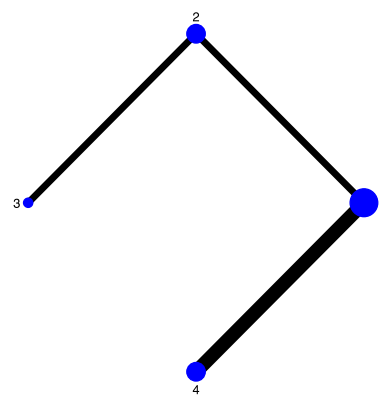
Figure 2. Risk of bias graph.

|                        | Random sequence generation (selection bias) | Allocation concealment (selection bias) | Blinding of participants and personnel (performance bias) | Blinding of outcome assessment (detection bias) | Incomplete outcome data (attrition bias) | Selective reporting (reporting bias) | Other bias |
|------------------------|---|---|---|---|--|--------------------------------------|------------|
| Faude et al., 2013     | +   | ?                                       | •   | ?   | +  | +                                    | +          |
| Hwang & Jooyoung, 2019 | +   | ?                                       | •   | ?   | +  | +                                    | ?          |
| Loturco et al., 2016   | +   | +                                       | •   | ?   | +  | +                                    | ?          |
| Ozbar et al., 2014     | +   | +                                       | •   | ?   | +  | +                                    | +          |
| Pedersen et al., 2019  | +   | +                                       | •   | •   | +  | +                                    | +          |
| Ramirez et al., 2016   | +   | +                                       | •   | ?   | +  | +                                    | +          |
| Riberio et al., 2020   | +   | ?                                       | +   | ?   | +  | +                                    | ?          |
| Rodríguez et al., 2017 | +   | ?                                       | •   | ?   | +  | +                                    | +          |
| Ronnestad et al., 2008 | +   | +                                       | +   | •   | +  | +                                    | +          |
| Shalfawi et al., 2013  | +   | ?                                       | •   | ?   | +  | +                                    | ?          |
| Spineti et al., 2019   | +   | ?                                       | •   | ?   | +  | +                                    | +          |

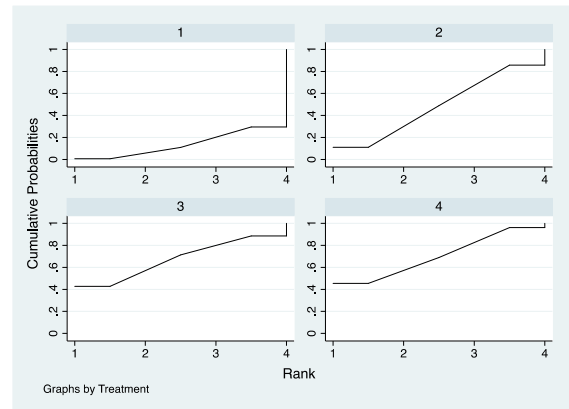
**Figure 3.** Risk of bias summary. (Green: low risk; Yellow: unclear risk; Red: high risk) [33–42].

### 3.4. Network Meta-Analysis

A total of 11 studies were included to analyze the sprinting ability and agility of soccer players. Of these, seven studies examined the effect on 10 m sprints, four studies examined the effect on 20 m sprints, and seven studies examined the effect on COD. The full NMA figures are shown in Figures 4–7.



(A)

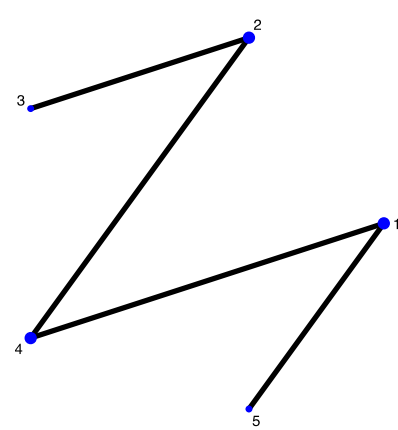


(B)

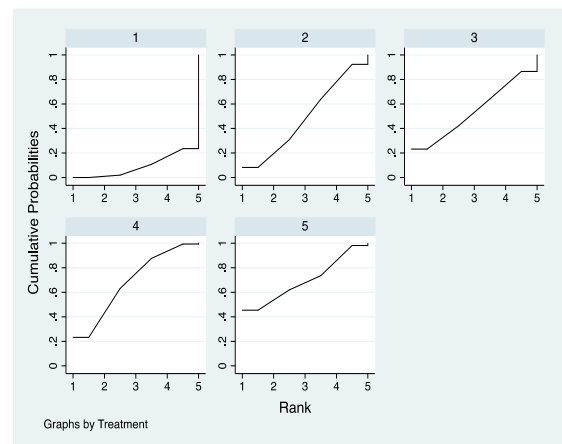
|                     |                     |                     |   |
|---------------------|---------------------|---------------------|---|
| 4                   |                     |                     |   |
| -0.02 (-1.16, 1.13) | 3                   |                     |   |
| -0.20 (-1.13, 0.74) | -0.18 (-0.86, 0.50) | 2                   |   |
| -0.51 (-1.10, 0.08) | -0.49 (-1.49, 0.50) | -0.32 (-1.06, 0.43) | 1 |

(C)

**Figure 4.** (A) NMA figure for 10 m sprint, (B) SUCRA plot for 10 m sprint; (C) league table of 10 m sprints. 1 = control group; 2 = resistance training group; 3 = plyometric training group; 4 = plyometric + resistance + sprint + agility training group.



(A)



(B)

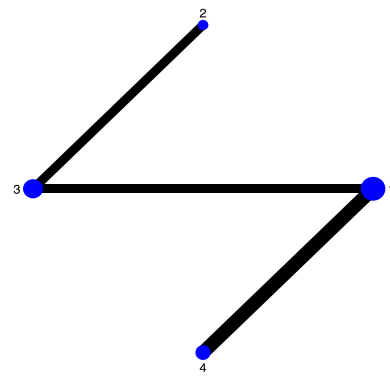
**Figure 5.** Cont.



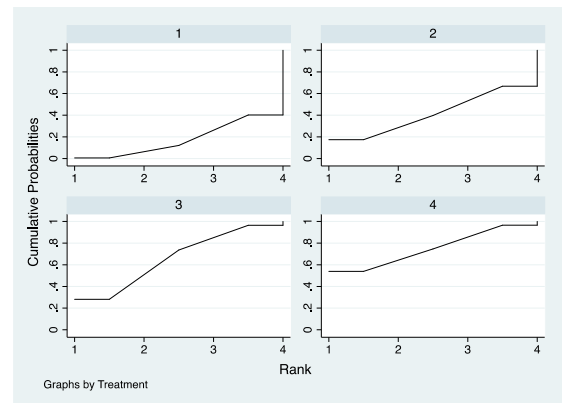
|                      |                     |                     |                     |   |
|----------------------|---------------------|---------------------|---------------------|---|
| 5                    |                     |                     |                     |   |
| -0.10 (-1.46, 1.27)  | 4                   |                     |                     |   |
| -0.26 (-2.09, 1.57)  | -0.16 (-1.38, 1.05) | 3                   |                     |   |
| -0.32 (-1.93, 1.28)  | -0.23 (-1.07, 0.62) | -0.06 (-0.94, 0.81) | 2                   |   |
| -1.02 (-2.02, -0.02) | -0.92 (-1.86, 0.01) | -0.76 (-2.29, 0.77) | -0.70 (-1.95, 0.56) | 1 |

(C)

**Figure 5.** (A) NMA figure for 20 m sprint; (B) SUCRA plot for 20 m sprint; (C) league table of 20 m sprint. 1 = control group; 2 = resistance training group; 3 = resisted sprint + agility training group; 4 = plyometric + resistance + sprint + agility training group; 5 = plyometric + sprint + agility training group.



(A)



(B)

|                     |                     |                     |   |
|---------------------|---------------------|---------------------|---|
| 4                   |                     |                     |   |
| -0.02 (-1.16, 1.13) | 3                   |                     |   |
| -0.20 (-1.13, 0.74) | -0.18 (-0.86, 0.50) | 2                   |   |
| -0.51 (-1.10, 0.08) | -0.49 (-1.49, 0.50) | -0.32 (-1.06, 0.43) | 1 |

(C)

**Figure 6.** (A) NMA figure for COD; (B) SUCRA plot for COD; (C) league table of COD. 1 = control group; 2 = resistance training group; 3 = plyometric training group; 4 = plyometric + resistance + sprint + agility training group.

### 3.4.1. Results for 10 m Sprint

The results of the NMA showed that, compared with the control group, group 4 (SMD = -0.51, 95% CI: -1.10–0.08), group 3 (SMD = -0.49, 95% CI: -1.49–0.50), and group 2 (SMD = -0.32, 95% CI: -1.06–0.43) were better than the control group at improving the 10 m sprint ability, as shown in Figure 4C. Group 4 ranked first for improving the 10 m sprinting ability with different training methods (SUCRA = 70.2%, as shown in Table 3).

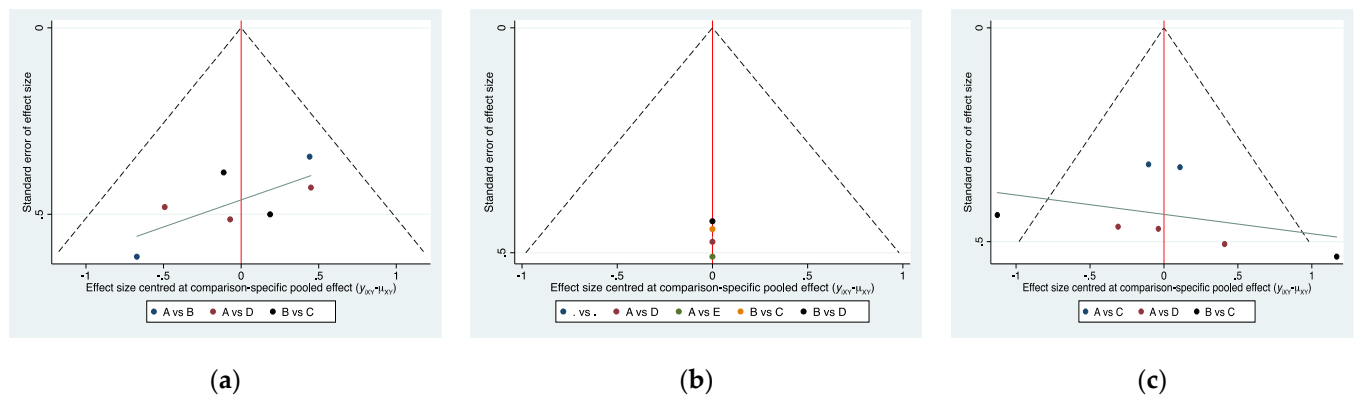


Figure 7. Funnel plot of publication bias. (a) 10 m sprint; (b) 20 m sprint; (c) COD.

Table 3. Rankings for 10 m sprint, 20 m sprint, and COD for different types of exercise.

| Exercise | 10 m Sprint |       |           | 20 m Sprint |       |           | COD   |       |           |
|----------|-------------|-------|-----------|-------------|-------|-----------|-------|-------|-----------|
|          | SUCRA       | P (%) | Mean Rank | SUCRA       | P (%) | Mean Rank | SUCRA | P (%) | Mean Rank |
| 1        | 13.7        | 0.7   | 3.6       | 9.1         | 0.0   | 4.6       | 17.6  | 0.6   | 3.5       |
| 2        | 48.5        | 11.1  | 2.5       | 48.8        | 8.2   | 3.0       | 41.3  | 17.4  | 2.8       |
| 3        | 67.5        | 42.8  | 2.0       | 54.0        | 23.2  | 2.8       | 66.0  | 28.1  | 2.0       |
| 4        | 70.2        | 45.5  | 1.9       | 68.3        | 23.2  | 2.3       | 75.0  | 53.9  | 1.7       |
| 5        |             |       |           | 69.8        | 45.4  | 2.2       |       |       |           |

Note: higher SUCRA and lower mean ranks indicate better-performing treatments. P indicates the probability of it being the best treatment.

### 3.4.2. Results for 20 m Sprint

The results of the NMA showed that, compared with the control group, group 5 (SMD = −1.02, 95% CI: −2.02–0.02), group 4 (SMD = −0.92, 95% CI: −1.86–0.01), 3 (SMD = −0.76, 95% CI: −2.29–0.77), and group 2 (SMD = −0.70, 95% CI: −1.95–0.56) were better than the control group in terms of improving the 20 m sprinting ability, as shown in Figure 5C. Group 5 ranked first for improving the 20 m sprinting ability with different training methods (SUCRA = 69.8%, as shown in Table 3).

### 3.4.3. COD

The results of the NMA showed that, compared with the control group, group 4 (SMD = −0.77, 95% CI: −1.71–0.16), group 3 (SMD = −0.61, 95% CI: −1.64–0.41), and group 2 (SMD = −0.29, 95% CI: −1.84–1.25) were better than the control group at improving the COD ability, as shown in Figure 6C. Group 4 ranked first at improving the COD ability (SUCRA = 75.0%, as shown in Table 3).

### 3.5. Publication Bias Test

We constructed separate funnel plots for all the outcome measures to test for possible publication bias. The visual inspection of the funnel plots was largely symmetrical, and there may have been some degree of publication bias [43]. The Egger test results showed that  $p > 0.05$  (10 m,  $p = 0.590$ ; 20 m,  $p = 0.117$ ; COD,  $p = 0.085$ ) with no publication bias. The details are shown in Figure 7.

## 4. Discussion

In this network meta-analysis (NMA), we considered 11 RCTs and compared the relative effects of six kinds of interventions for soccer players' sprinting and COD abilities. The results of the study showed that, in terms of combined training, P+T+S+A had the best

effect on soccer players' 10 m sprint and COD abilities. P+S+A had the best effect on soccer players' 20 m sprint abilities. For the single training mode, plyometrics had the best effect.

First, for the single training mode, our findings supported the previous findings of Pardos et al., in that plyometric training had better effects than strength training [21]. Plyometrics take advantage of the stretch–shortening cycle (SSC), the muscle–tendon eccentric stretch, concentric contraction, and the ability to transfer this energy to the concentric push-out phase [44,45]. Simultaneously, it improves neuromuscular function (intermuscular coordination, size structure, and mechanical changes) and does not involve external resistance, providing excellent performance conversion [46,47]. Squat jumping exercises can effectively enhance muscle power output, while reverse jumping improves muscle coordination and increases the ground reaction force [48]. Second, SSC exercises enhance single-fiber contractility through the force and contraction velocity of type I, IIa and IIa/IIx fibers, increased fiber strength, contraction velocity, increased Ca sensitivity, and fiber size [49]. Finally, Jiménez et al. verified the sprint and force–velocity (F–V) correlation; some jumping exercises based on the F–V curve can provide positive adaptation, and imitating the action pattern can explain its enhanced sprinting ability [50–53]. In terms of COD, the enhancement of neuromuscular function and eccentric strength can allow an athlete to better decelerate during a change of direction [54,55]. The insufficiency of simple training intensity, the generation of residual fatigue effects, and concurrent training reduce strength training adaptability and thus affect athletes' sprinting performance [56].

Second, in the 20 m sprint, the combined training mode (plyometric training combined with resistance or sprint training) had better benefits than the single training mode. This is a training method recommended by many coaches and researchers [57,58]. Also supporting the previous findings of Rumpf et al. [59] and Nicholson et al. [60], combining level 3 training (plyometric or strength training) with specific sprint training (free sprint, assisted sprint, etc.) is more effective for short sprints than simple training. Combined training provides sufficient stimulation to simultaneously develop the physical fitness and mechanical efficiency of the lower extremities, reducing cadence and increasing stride length [61].

It is worth noting that P+S+A in the combined training mode was better than P+T+S+A in terms of 20 m sprinting. This kind of concurrent training will reduce the adaptability of training and interfere with the training effect [56]. Thus, P+T+S+A is not as effective. At the same time, the adjustment variable will also have an impact on the training effect [62]. The results of studies on the effects of strength training on soccer players of different ages show that younger players have greater training benefits [63]. As shown in our included studies with athletes aged 18 in the study of P+S+A and athletes aged 18–24 in P+T+S+A, this is one of the reasons why P+S+A works better.

Third, the experimental and control groups that we analyzed in the study conducted tactical soccer training and a small-side game. Some studies have reported that small-side games positively affect agility and 10 m and 20 m sprints [64–66]. Given these points, it is considered that these aspects require future research.

Finally, the size of many effect estimates depends on indirect comparisons based on reliability, and more research on multi-arm designs should be conducted in the future.

#### *Limitations of the Study*

(1) Heterogeneity between the original studies was inevitable, and some studies were unobtainable, which affected the validity of the NMA to a certain extent. (2) Since only English articles were included, the number of previous RCT studies was insufficient. Our NMA also did not compare assisted or sled sprints, iso-inertial eccentric-overload training methods, and the SAQ training method in COD. (3) The effects of moderator variables on the assessment results were also not statistically analyzed, e.g., age and sex. (4) As the capacity to detect bias will be limited when meta-analyses are based on a limited number of small trials, the results from the analyses should be treated with considerable caution [67]. (5) Only two studies were studied with professional players, and the others were semi-professional players.

## 5. Conclusions

In conclusion, our study has implications for relevant practitioners and researchers such as soccer coaches who could design conditioning protocols based on our results. In our analysis, the top-ranked intervention for improving sprint and COD performance in soccer players was plyometric combined with resistance, sprint, and agility training, while the highest-performing one of the single modes was plyometric training. Therefore, if a variety of training is allowed for a coach, he/she should choose P+T+S+A to improve sprint and COD performance. However, if time does not permit this or if there is only one training choice, choosing plyometrics would be the most effective way to improve an athlete's sprinting and COD performance. In addition, positive effects can be expected if the training period is longer than six weeks. However, given the limitations of the above analysis, these results should be interpreted with caution. In the future, more multi-armed RCTs should be performed to provide more direct evidence for the relative effectiveness of various exercise interventions.

**Author Contributions:** Conceptualization, K.D. and B.C.; methodology, K.D. and B.C.; software, K.D. and B.C.; validation, G.J. and K.D.; formal analysis, K.D.; resources, K.D. and G.J.; data curation, K.D.; writing—original draft preparation, K.D.; writing—review and editing, K.D., G.J. and B.C.; visualization, K.D.; supervision, G.J. and B.C.; project administration, K.D. and B.C. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable. This study was a secondary analysis of publicly available data, therefore ethical review and consent were not required.

**Informed Consent Statement:** Not applicable. This study was a secondary analysis of publicly available data, therefore Informed consent statement were not required.

**Data Availability Statement:** The data that support the findings of this study are available from the corresponding author, [B.C.], upon reasonable request.

**Conflicts of Interest:** The authors declare no conflict of interest.

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