

Effect of additional short sprint training on physical performance in adolescent male soccer players: a systematic review and meta-analysis

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Purpose: The aim of this systematic review with meta-analysis (SRMA) was to evaluate the effects of additional short sprint training with different intervention training programs (i.e. plyometric training, strength training or multidirectional training) on linear sprint, change of direction speeds (CODS) and jump ability performance in young male soccer players.

Methods: An electronic database search was performed, and 7 articles were included in the meta-analysis.

Results: The players' mean age ranged from 7.6 to 18.8 years. The duration of combined interventions was from three weeks to 10 months, with training frequency ranging from one to two sessions per week. In general, the results of the performance were associated with a large and significant reduction in the time of CODS (ES -1.60 (95% CI -2.33, -.87), $Z=4.32$ ($P<.001$)). Moreover, the effects on vertical jump height showed a non-significant and small improvement between pre and post-test on the vertical jump performance [ES .45 (95% CI - .14, .75), $Z=2.90$ ($P=.004$)], with an average heterogeneity of $I^2 = 0\%$.

Conclusions: The current SRMA suggests that although additional short sprint training may produce improvements in certain aspects of performance, efficacy varies depending on individual and training-specific factors.

Keywords: football, athletic performance, youth, jump performance, agility

Introduction

Short sprint is an important skill for soccer players¹. During the game, this kind of action is related to short durations and high-intensity²⁻⁴ that could decide the most important actions such as score the goal, winning or losing duels, or even in determining the outcome of the game⁵. Moreover, during the game, there are some situations where repeated sprints occur without or with short rest periods between them which are also considered key actions for decisive moments of the game⁶.

In this sense, optimal performance is needed to produce different kind of forces and explosive actions such as short sprints are crucial⁷. Moreover, soccer involves more actions than sprints such as walking, standing, and jogging, that take place during a soccer match⁸.

In addition to those actions, linear movements and non-linear movements are produced during the game. Changes of direction (COD) could develop a major role during the game⁹. These changes are associated with the capacity of a player to accelerate, decelerate, and reaccelerate in different directions¹⁰.

The ability to jump is another major factor that is related to special contributions to the performance potential of soccer players¹¹. Considering the information above, there were different

training protocols such functional training, traditional strength training, and plyometric training that have revealed significant and positive effects on neuromuscular performance, such as sprint, COD, and jump performance¹². Furthermore, in the context of training for young soccer players, there are several practices, e.g. tactical and technical sessions, strength and conditioning sessions. In science it is difficult to create the best environment to study the effect of producing other kind of training. Recently, it was suggested to add combined plyometric and speed exercises to supplement normal soccer training to improve COD, LS, and RSA performance¹³.

Another recent systematic review and meta-analysis that aimed to analyse training interventions upon short sprint performance within soccer, American football, Canadian football, Australian rules football, rugby union, rugby league, rugby sevens, Gaelic football, futsal however without focusing on COD and jump ability¹⁴.

Since sprints are some of the most important actions in the sport and can have impact on the outcomes of the game, the main purpose of this systematic review and meta-analysis was to evaluate the effects of additional short sprints on linear sprint, COD speed and jump ability performance in youth male soccer

players.
Therefore, the main purpose of this systematic review and meta-analysis (SRMA) was to evaluate the effects of additional short sprint training with different intervention training programs (i.e. plyometric training, strength training or multidirectional training) on linear sprint, change of direction speed (CODS) and jump ability performance in youth male soccer players.

Methods

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines ¹⁵ as well as the guidelines for performing systematic reviews in sport sciences ¹⁶ were followed to write this SRMA. Moreover, the SRMA was registered in the PROSPERO database with the number CRD42024503692.

Information sources and search strategy

A comprehensive search of the PubMed, Web of Science, Google Scholar, and SportDiscus databases was carried out until June 4, 2024. Only articles written in Spanish and English were taken into account. We used the following search terms with Boolean operators: (“male” OR “men”) AND (“soccer” OR “football”) AND (“youth” or “adolescent”) AND (“mixed

training” OR “concurrent training” OR “combined training” OR “sprint training” OR “high-intensity interval training” OR “high intermittent training“ OR “HIIT” OR “speed training” OR “sprint interval training” OR “repeated sprint training” OR “speed endurance training” OR “plyometric training” OR “strength training” OR “resistance training” OR “agility training” OR “change of direction training” OR “power training”) AND (“change of direction” OR “agility” OR “jump” OR “sprint” OR “speed”).

Before examining article abstracts and complete published papers, all relevant article titles were reviewed to determine which studies should be included. Only peer-reviewed articles were used in the meta-analysis. The search process is outlined in Figure 1. Additional manual searches were carried out in addition to the systematic searches.

Eligibility criteria and selection process

A PICOS (participants, intervention, comparators, outcomes, and study design) approach was used to rate studies’ eligibility ¹⁶. The respective inclusion/exclusion criteria adopted in our meta-analysis are reported in Table 1.

Table 1. Inclusion and exclusion criteria

Category	Inclusion Criteria	Exclusion Criteria
Population	Cohorts of youth male soccer players among 8 and 19 years.	Studies having only female or combined sex participants
Intervention/Exposure	A combined sprint training program, defined as a combination of short sprints exercise and plyometric/power and change of direction strength exercise	Exercise interventions not involving combined of short sprints with intervention training programs.
Comparator	Active control group or another experimental group	Absence of active control group or another experimental group
Outcome	At least one measure of physical fitness (linear sprinting, jumping, and change of direction speed) before and after the training intervention	Lack of baseline and/or follow-up data
Study design	Randomized/Nonrandomized controlled trial	Cross-sectional study
Other	Only original and full-text studies written in English and Spanish	Not written in English and Spanish. Non-original, full research articles (e.g., reviews, letters to editors, trial registrations, proposals for protocols, editorials, book chapters, and conference abstracts).

Data collection process

In selecting studies for inclusion, a review of all relevant article titles was conducted before an examination of article abstracts and then full-published articles. Two authors conducted the process independently. Potential discrepancies between the two reviewers about study conditions were resolved by consensus with a third author. Full-text articles excluded, with reasons, were recorded. Data were extracted from gathered articles by two authors independently, using a form created in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA).

The extraction of data from gathered articles was undertaken by two reviewers.

Data items

Aiming to establish consistency in data analysing and reporting, only measures that were analysed three or more times for different articles were included. Three main outcomes were considered for extraction: (i) linear sprint, (ii) CODS, and (iii) vertical jump.

The linear sprint at different distances was collected including

values of partial times. The CODS time was usually measured at different tests such as Illinois agility test, ten meters agility test or 505 CODS test. The vertical jump was regularly assessed during a countermovement jump (CMJ) without arm swing, an Abalakov jump and a squat jump. In addition, the following information was extracted from the included studies: (i) number of participants (n), age (years), body mass (BM) (kg), height (cm), and competitive level; (ii) number of sessions per week (n/w), period of intervention (number of weeks), and regimen of intervention.

Methodological assessment

For this review, only studies that met the eligibility criteria were selected. Reviewers independently assessed the methodological quality of the eligible studies using the PEDro scale¹⁷. This scale evaluates internal study validity on a scale from 0 (high risk of bias) to 10 (low risk of bias) to each methodological item listed in Table 1. A score of ≥ 4 represents the threshold for studies with a low risk of bias. Two of the authors independently scored the articles. Disagreements in the rating between both authors was resolved through discussion. Aiming to control the risk of bias between authors, the Kappa correlation test was used to analyse the agreement level for the included studies. The a priori agreement rate between reviewers was set at $k \geq .80$.

Statistical Analyses

Meta-analytical comparisons were carried out in RevMan version 5.3¹⁸. Included were 8 studies that comprised 10 individual experimental groups. Means and standard deviations for a measure of post-intervention performance within experimental group (pre- vs. post-test) and between groups (experimental vs. control group) were used to calculate an effect size (ES). ESs were adjusted using Hedges' small sample size bias correction¹⁹. The

inverse-variance random effects model for meta-analyses was used because it allocates a proportionate weight to trials based on the size of their individual standard errors²⁰, and facilitates analysis whilst accounting for heterogeneity across studies¹⁹. ESs are represented by the standardised mean difference (Hedges' *g*) and are presented alongside 95% confidence intervals (CI). The calculated ESs were interpreted using the conventions outlined for standardised mean difference by Hopkins et al.²¹ ($< .2$ = trivial; $.2-.6$ = small, $> .6-1.2$ = moderate, $>1.2-2.0$ = large, $>2.0-4.0$ = very large, >4.0 = extremely large).

In a case in which there was more than one intervention group in a given study, the control group was proportionately divided to facilitate comparison across all participants²².

To gauge the degree of heterogeneity amongst the included studies, the I^2 statistic was referred to. This represents the proportion of effects that are due to heterogeneity as opposed to chance. Low, moderate and high levels of heterogeneity correspond to I^2 values of 25%, 50% and 75% respectively; however, these thresholds are considered tentative²³. The χ^2 (chi square) statistic determines if any observed differences in results are compatible with chance alone. A low P value, or a large χ^2 statistic, relative to its degrees of freedom provides evidence of heterogeneity of intervention effects beyond those attributed to chance²⁰.

Analysis of Moderator Variables

To assess the potential effects of moderator variables, subgroup analyses were performed. This method was preferred to meta-regression based on documented limitations of the latter method when applied to small datasets with low simple sizes and few predictor variables²⁴. Using a random-effects model, potential sources of heterogeneity likely to influence the effects of training were selected a priori. The moderator variables of program

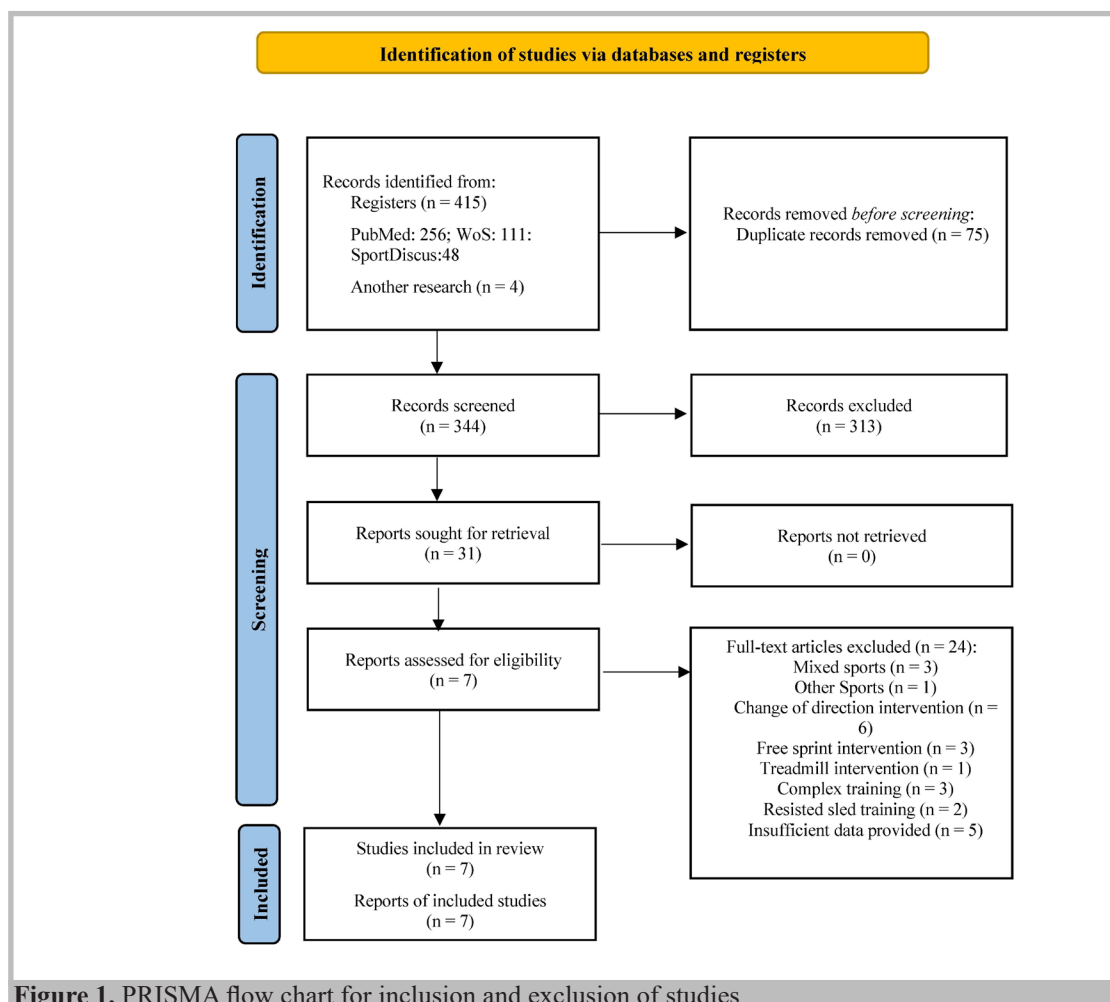


Figure 1. PRISMA flow chart for inclusion and exclusion of studies

duration (weeks), training frequency (sessions per week), and athlete's competition level. Meta-analyses stratification by each of these factors was performed, with a *P* value of < .05 considered as the threshold for statistical significance.

Results

Study selection

A total of 806 studies were found in the identification phase. Duplicates, meta-analysis and systematic reviews (314 references) were subsequently removed. The remaining 492 articles were screened for their relevance based on titles and

abstracts, resulting in the removal of a further 336 studies. The full texts of the remaining 156 articles were examined diligently, 125 were excluded. Following the screening procedure, 31 were selected for in depth reading and analysis. After reading full texts, further 23 studies were excluded due to several reasons (Figure 1). Finally, 7 studies were included in the systematic review and meta-analysis.

Methodological Quality

The selected studies were submitted to the PEDro methodological quality scale. Three studies obtained a score of 6/10²⁵⁻²⁷ and four obtained 5/10²⁸⁻³¹. Table 2 displays full details of the PEDro

Table 2. The Physiotherapy Evidence Database (PEDro) scale ratings.

Studies	N°1	N°2	N°3	N°4	N°5	N°6	N°7	N°8	N°9	N°10	N°11	Total ¹
Born et al. (2016) ²⁸	1	0	0	1	0	0	0	1	1	1	1	5
Campos-Vázquez et al. (2015) ²⁵	1	1	0	1	0	0	0	1	1	1	1	6
Ferrete et al. (2014) ²⁶	1	1	0	1	0	0	0	1	1	1	1	6
Kargardard et al. (2020) ²⁹	1	0	0	1	0	0	0	1	1	1	1	5
Keiner et al. (2022) ³⁰	1	0	0	1	0	0	0	1	1	1	1	5
Mathisen et al. (2014) ³¹	1	0	0	1	0	0	0	1	1	1	1	5
Sáez de Villareal et al. (2015) ²⁷	1	1	0	1	0	0	0	1	1	1	1	6

¹ The total number of points from a possible maximal of 10.

scale score of each study.

Study characteristics

The characteristics of the participants and combined of short sprints with additional training programs parameters from the 7

studies incorporated in the meta-analysis are indicated in Table 3 and Table 4, respectively. The included studies comprised 212 adolescent male soccer players eligible. The participants' mean age across the studies extends from 7.6 to 18.8. The duration

Table 3. Characteristics of study participants included in the meta-analysis

Study	Study Group	N	Age (years)	BM (kg)	Heigh (cm)	Level
Born et al. (2016) ²⁸	MTG: 10 CODG: 9	19	14 ± .6	59 ± 12	1.74 ± .08	Highly trained
Campos-Vázquez et al. (2015) ²⁵	SG: 10 TG: 11	21	18.1 ± .8	69.9 ± 6.5	177.1 ± 5.7	Trained
Ferrete et al. (2014) ²⁶	CHIIT: 13 CG: 11	24	8.79 ± 1.2	31.7 ± 9.6	133.7 ± 11.6	Highly trained
Kargardard et al. (2020) ²⁹	CHIITW: 9 CHIITD: 8 CG: 7	24	17.9 ± .9	64.6 ± 8.7	178.2 ± 12.6	Trained
Keiner et al. (2022) ³⁰	CHIIT: 11 SG: 11 FG: 14 CG: 12	64	17.5 ± .5	73 ± 7	178 ± .06	Highly trained
Mathisen et al. (2014) ³¹	CHIIT: 14 CG: 20	34	13.5 ± .8	-	-	Trained
Sáez de Villareal et al. (2015) ²⁷	CHIIT: 13 CG: 13	26	15.1 ± .6	55.8 ± 12.4	166.6 ± 13.1	Highly trained

BM: body mass; CHIIT: combined high interval intensity training; MTG: multidirectional group; CODG: change of direction group; SG: squat group; TG: take-offs group; CHIITW: combined high interval intensity training weekly; CHIITD: combined high interval intensity training daily; CHIIT1: one day of combined high interval intensity training CHIIT2: two days of combined high interval intensity training; SG: Strength group; FG: Functional group; CG: control group

of combined interventions from 3 weeks to 10 months, with *Main effect*
training frequency ranges from 1 to 2 sessions per week. The data used for meta-analyses are displayed in Table 5.

Table 5. Performance (mean, standard deviation and number of players) in physical fitness tests.

Study	Test	Experimental (pre-test)			Control (pre-test)			Experimental (post-test)			Control (post-test)		
		Mean	SD	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>n</i>
Linear sprint test (s)													
Born et al. (2016) (MTG) ²⁸	20m	3.26	.15	10				3.32	.20	10			
Born et al. (2016) (CODG) ²⁸		3.32	.20	9				3.37	.16	9			
Ferrete et al. (2014) ²⁶	15m	2.7	.1	13	2.8	.1	11	2.9	.1	13	2.9	.1	11
Kangarfard et al. (2020) (CHIITD) ²⁹	30m	4.21	.24	9				4.00	.07	9			
Kangarfard et al. (2020) (CHIITW) ²⁹		4.29	.21	8	4.28	.24	7	4.23	.17	8	4.33	.21	7
Keiner et al. (2022) ³⁰	20m	3.18	.10	11	3.19	.10	12	3.17	.10	11	3.22	.09	12
Mathisen et al. (2014) ³¹	10m	2.02	.11	14	2.00	.11	20	1.96	.11	14	2.02	.12	20
Mathisen et al. (2014) ³¹	20m	3.54	.17	14	3.55	.19	20	3.42	.18	14	3.58	.20	20
Sáez de Villareal et al. (2015) ²⁷	5m	0.81	.1	13	0.80	.1	13	0.74	.1	13	.83	.1	13
Sáez de Villareal et al. (2015) ²⁷	10m	1.87	.1		1.78	.1		1.91	.1		1.93	.1	
Change of direction speed test (s)													
Born et al. (2016) (MTG) ²⁸	Illinois agility test	17.8	.3	10				17.3	.5	10			
Born et al. (2016) (CODG) ²⁸		18.2	.9	9				17.8	.6	9			
Kangarfard et al. (2020) (CHIITD) ²⁹	COD test	2.67	.11	9				2.56	.13	9			
Kangarfard et al. (2020) (CHIITW) ²⁹		2.80	.13	8	2.70	.12	7	2.66	.19	8	2.70	.12	7
Keiner et al. (2022) ³⁰	CODR test	3.14	.09	11	3.19	.10	12	3.13	.07	11	3.19	.10	12
	CODL test	2.94	.08		2.93	.07		2.93	.07		3.05	.05	
Mathisen et al. (2014) ³¹	Agility test	8.23	.34	14	8.25	.25	20	7.69	.34	14	8.18	.12	20
Sáez de Villareal et al. (2015) ²⁷	Agility R test	4.15	.3	13	4.18	.1	13	3.82	.1	13	4.15	.1	13
	Agility L test	4.26	.3		4.29	.1		4.01	.1		4.25	.1	
Vertical jump (cm)													
Born et al. (2016) (MTG) ²⁸	CMJ	35.7	7.1	10				34.9	6.3	10			
Born et al. (2016) (CODG) ²⁸		32.0	8.8	9				33.1	9.1	9			
Campos-Vázquez et al. (2015) (SG) ²⁵	CMJ	43.8	6.9	10				45.9	5.8	10			
Campos-Vázquez et al. (2015) (TG) ²⁵		43.3	4.33	11				44.8	5.21	11			
Ferrete et al. (2014) ²⁶	CMJ	22.3	2.7	13	20.2	3.4	11	23.8	4.3	13	18	3.6	11
Keiner et al. (2022) ³⁰	SJ	40.2	3.4	11	35.4	3.1	12	41.3	3.9	11	35.2	3.0	12
Sáez de Villareal et al. (2015) ²⁷	CMJ	31.8	3.2	13	30.9	3.8	13	34.8	3.5	13	31.2	3.7	13
Sáez de Villareal et al. (2015) ²⁷	Abalakov	34.7	4.1		33.4	3.8		40.1	4.2		33.7	3.9	

MTG: multidirectional group; CODG: change of direction group; COD: change of direction; ST: strength training; SG: squat group; TG: take-offs group; VJ: vertical jump; CMJ: countermovement jump; DJ: drop jump; HJ: horizontal jump; SJ: squat jump; R: right; L: left

Linear sprint time

Six studies were included in this systematic review and meta-analysis²⁶⁻³¹. The results of the overall effects on sprint time showed a non-significant improvement between pre- and post-test on the time of linear sprint (ES -.06 (95% CI -.55, .44), $Z=.23$ ($P=.82$)). There was a significant level of between-study heterogeneity [$I^2 = 70\%$ ($P=.0005$)]. Moreover, in the

studies that included a control group^{26,27,29-31}, significant and small improvement was found in participants belonging to the experimental group compared with the control group (ES -.59 (95% CI -.93, -.25), $Z=3.38$ ($P=.0007$)), with an average heterogeneity of $I^2 = 25\%$.

These results are displayed in Figure 2 (baseline vs. follow-up) and Figure 3 (experimental vs. control).

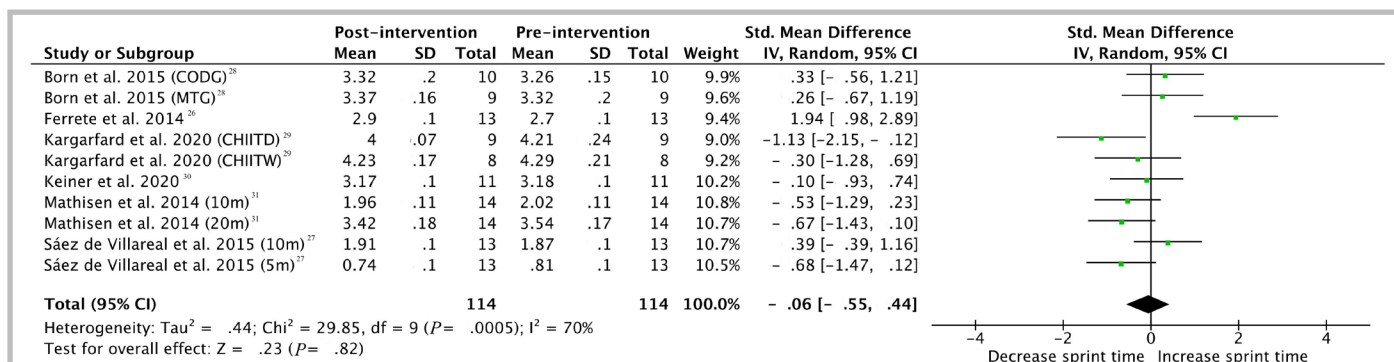


Figure 2. Forest plot of between-mode effect sizes with 95% confidence intervals (CIs) in the time of linear sprint (s). IV inverse variance method, SD standard deviation, Std standardized.

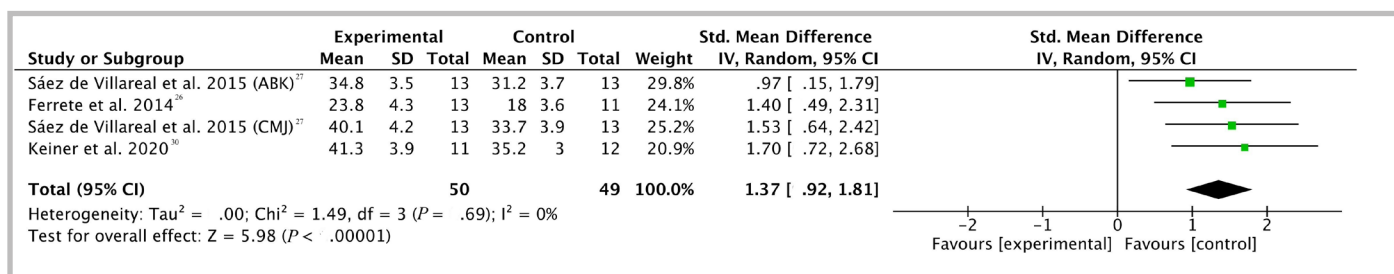


Figure 3. Forest plot of within-mode effect sizes with 95% confidence intervals (CIs) in the time of linear sprint (s). IV inverse variance method, SD standard deviation, Std standardized.

CODS time

Four effects were analysed from 7 original studies²⁷⁻³¹. The CODS performance was measured in seconds. The performance of training program was associated with a large and significant reduction in the time of CODS (ES -1.60 (95% CI -2.33, -.87), $Z=4.32$ ($P<.0001$)). There was not a significant level of between-study heterogeneity [$I^2 = 53\%$ ($P=.07$)]. In addition, in the studies

that included a control group^{27,29-31}, a significant improvement was found in participants belonging to the combined training compared with the control group (ES -.84 (95% CI -1.20, -.49), $Z=4.65$ ($P<.00001$)), with an average heterogeneity of $I^2 = 29\%$. These results are displayed in Figure 4 (baseline vs. follow-up) and Figure 5 (experimental vs. control).

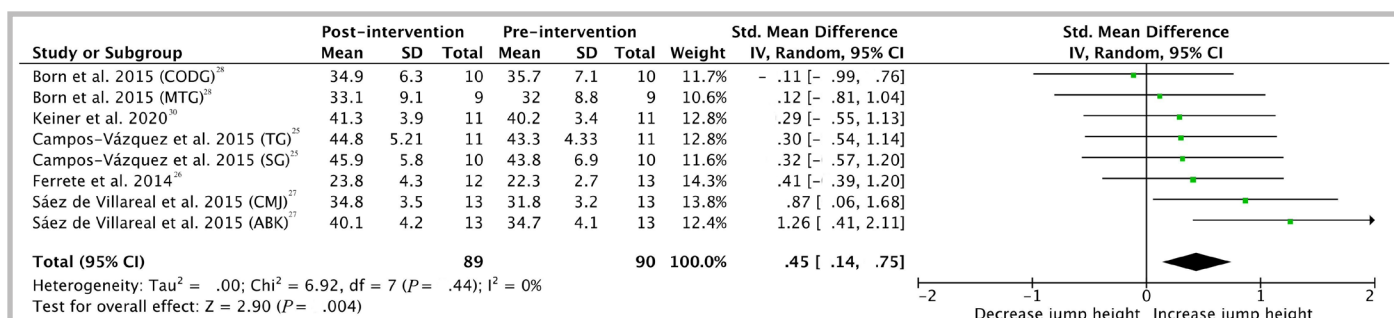


Figure 4. Forest plot of between-mode effect sizes with 95% confidence intervals (CIs) in the time of change of direction (s). IV inverse variance method, SD standard deviation, Std standardized.

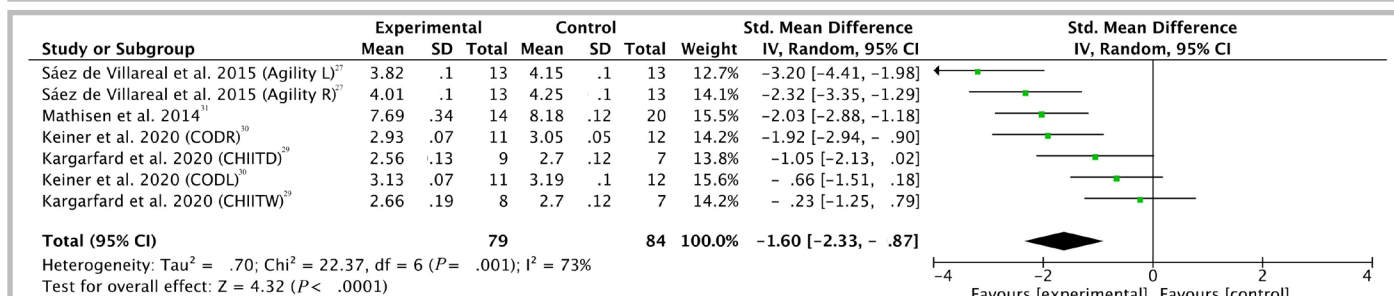


Figure 5. Forest plot of within-mode effect sizes with 95% confidence intervals (CIs) in the time of change of direction (s). IV inverse variance method, SD standard deviation, Std standardized.

Vertical jump performance

Five effects were analysed from 7 original studies^{25-28,30}. Vertical jump height was measured in centimeters. The results of the overall effects on vertical jump height showed a non-significant and small improvement between pre- and post-test on the vertical jump performance [ES .45 (95% CI = .14, .75), $Z=2.90$ ($P=.004$)], with an average heterogeneity of $I^2=0\%$.

Furthermore, the studies with a control group^{26,27,30} found a non-significant improvement in the combined training compared with the control group [ES 1.37 (95% CI = .92, 1.81), $Z=5.98$ ($P<.00001$)], with an average heterogeneity of $I^2=0\%$. These results are displayed in Figure 6 (baseline vs. follow-up) and Figure 7 (experimental vs. control).

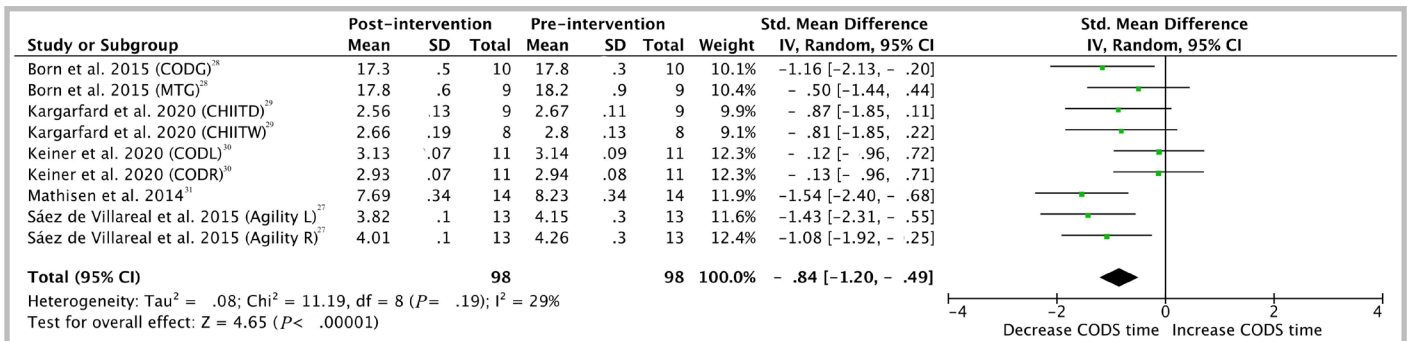


Figure 6. Forest plot of between-mode effect sizes with 95% confidence intervals (CIs) in vertical jump performance (cm). IV inverse variance method, SD standard deviation, Std standardized.

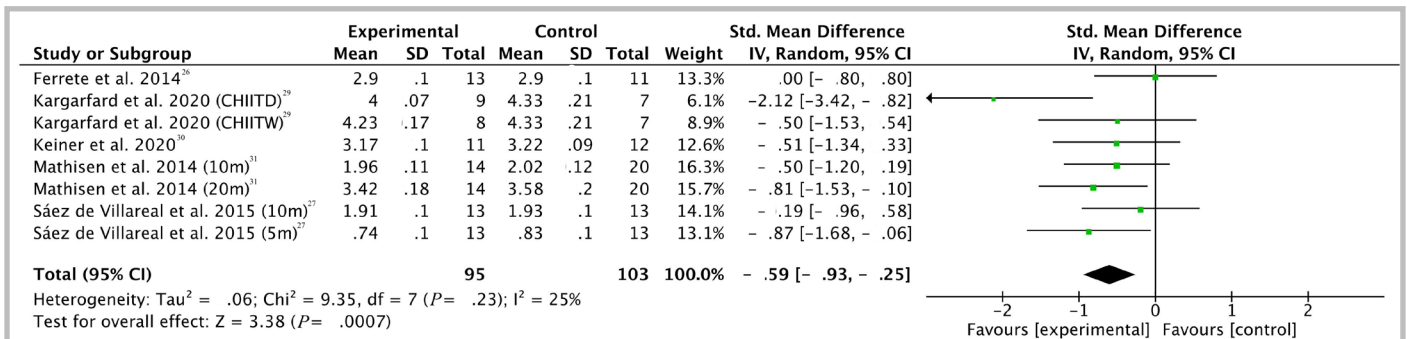


Figure 7. Forest plot of within-mode effect sizes with 95% confidence intervals (CIs) in vertical jump performance (cm). IV inverse variance method, SD standard deviation, Std standardized.

Effect of Moderator Variables

in Table 6.

A summary of the effect of moderator variables can be viewed

Table 6. Effect of moderator variables with 95% confidence intervals in combined of short sprints with intervention programs.

Variable		Subgroup	Groups	Effect Size with 95% CI	Effect Descriptor	Within- Group I ² (%)	Within- Group <i>P</i> ^a	Between Group I ² (%)	Between Group <i>P</i> ^b
Linear sprint test (s)	D	≤ 6 weeks	4	-.18 (-.83; .47)	Trivial	46	.59	0	.67
		> 6 weeks	6	.03 (-.70; .76)	Trivial	79	.94		
	F	1 sessions/ weeks	3	-.71 (-1.19; -.24)	Moderate	0	.003	83.8	.01
		> 1 sessions/ weeks	7	.25 (-.34; .84)	Small	69	.41		
	L	Trained	4	-.64 (-1.06; -.21)	Moderate	0	.004	82.6	.02
		Highly trained	6	.33 (-.33; 1.00)	Small	72	.33		
Change of direction speed test (s)	D	≤ 6 weeks	4	-.83 (-1.32; -.34)	Small	0	.0001	0	.96
		> 6 weeks	5	-.85 (-1.46; -.25)	Small	61	.0006		
	F	1 sessions/ weeks	3	-1.13 (-1.67; -.58)	Moderate	0	.0001	18.3	.27
		> 1 sessions/ weeks	6	-.72 (-1.18; -.27)	Moderate	39	.002		
	L	Trained	3	-1.13 (-1.67; -.58)	Moderate	0	.0001	18.3	.27
		Highly trained	6	-.72 (-1.18; -.49)	Moderate	39	.002		

Vertical jump (cm)	D	≤ 6 weeks	1	-0 (-.64; .63)	Trivial	0	.99	59.5	.12
		> 6 weeks	4	.57 (.23; .92)	Small	0	.001		
	F	1 sessions/ weeks	0					NE	NE
		> 1 sessions/ weeks	5	.45 (.14; .75)	Small	0	.004		
	L	Trained	3	.31 (-.30; .92)	Small	0	.32	0	.63
		Highly trained	2	.49 (.09; .88)	Small	25	.02		

F: frequency; L: playing level; D: duration; NE: not estimable; CI: confidence interval

Linear sprint time

Regarding the population characteristics, significant improvements and a moderate effect were found for trained groups (ES -.64 [95%CI = -1.06; .21], $Z = 2.91$ [$P = .004$]).

Regarding the exercise characteristics, significant improvements a moderate effect were obtained for a training frequency over once a week (ES -.71 [95%CI = -.34; .84], $Z = 2.95$ [$P = .003$]). However, non-significant improvements were found for training period duration ($P > .05$).

The level of heterogeneity was higher in subgroups with higher training frequency and lower level. In addition, between subgroups analyses revealed significant ($P < .05$) differences for training frequency and player's level.

CODS time

Regarding the population characteristics, combined interventions that included trained groups (ES -1.13 [95%CI = -1.67; .58], $Z = 4.03$ [$P = .0001$]) and highly trained groups (ES -.72 [95%CI = -1.18; .49], $Z = 3.09$ [$P = .002$]) demonstrated a moderate effect, with no significant subgroup differences ($P = .27$). Regarding the exercise characteristics, combined interventions with a training frequency of 1 session per week (ES -1.13 [95%CI = -1.67; .58], $Z = 4.03$ [$P = .0001$]) and 2 or more sessions per week (ES -.72 [95%CI = -1.18; .49], $Z = 3.09$ [$P = .002$]) produced a moderate effect, with no significant subgroup differences ($P = .27$). The combined interventions that lasted less than 6 weeks (ES -.83 [95%CI = -1.32; .34], $Z = 3.34$ [$P = .0001$]) and 6 weeks or longer (ES -.85 [95%CI = -1.46; .25], $Z = 2.75$ [$P = .0006$]) demonstrated a small effect, with no significant subgroup differences ($P = .96$).

The level of heterogeneity was higher in subgroups with higher training frequency, period duration and level.

Vertical jump performance

Regarding the population characteristics, significant improvements and a small effect were found for highly trained group (ES .49 [95%CI = .09; .88], $Z = 2.38$ [$P = .02$]).

Regarding the exercise characteristics, significant improvements and a small effect were obtained for a training frequency that included more than 1 session (ES -.45 [95%CI = .14; .75], $Z = 2.90$ [$P = .004$]) and a training duration that lasted 6 weeks or longer (ES .57 [95%CI = .23; .92], $Z = 3.30$ [$P = .001$]).

The level of heterogeneity was higher in subgroups with higher level. Furthermore, between subgroups analyses did not reveal significant ($P > .05$) differences for any variable.

Discussion

The present SRMA aimed to evaluate the effects of additional short sprints to training programs on linear sprint, CODS and jump ability performance in youth male soccer players. In terms of linear sprint, the primary findings concerned trials with a

control group; individuals in the experimental group showed a small but statistically significant improvement as compared to the control group^{26,27,29,30}. Moreover, the performance of the training program was associated with a large and significant reduction in the time of CODS. Additionally, compared to the control group in the studies with a control group, individuals in the combined training group showed considerable improvement. Finally, a significant effect was found regarding vertical jump performance.

Linear sprint time

Our findings demonstrate that significant improvements, with a moderate effect size, were observed in the trained groups, evidenced by an ES of -.64. This suggests that the interventions or training programs used within these groups had a significant impact.

Strength training appears to help young soccer players become more competent in sprinting, as supported by several studies. Additional research has explored how speed training or sprinting against resistance could improve sprinting performance. It can be inferred that training programs often demonstrate that a combination of techniques is more effective than independent strategies in improving performance. In this line, Rumpf et al. observed that specific sprint training methods, including resisted sprinting, are beneficial over various distances, suggesting the importance of incorporating various training modalities to optimize sprint performance in young athletes³².

Despite the absence of a significant overall improvement in sprint times (ES: -.06, $P = .82$), implying that the interventions, taken together, did not lead a significant impact in linear sprint performance, this result does not detract from the significant improvements in studies with control groups, where a small but significant improvement was observed in participants in the experimental groups (ES: -.59, $P = .0007$). The considerable heterogeneity between studies ($I^2 = 70\%$, $P = .0005$) means substantial variability in the effects of interventions, likely due to differences in study methodologies, participant populations, or specific interventions. implemented.

Furthermore, the improvement in the experimental groups, particularly compared to the control groups and with reduced heterogeneity ($I^2 = 25\%$), supports the effective-ness of certain interventions, such as the combination of short sprints and plyometric training. Petrakos et al. show that resisted sled sprint training can provide an effective program to improve sprint acceleration and maximum speed, highlighting the potential benefits of integrating resistance training into exercises. sprint for young soccer players³³.

Regarding exercise characteristics, our findings show the importance of training frequency. Notable improvements with a moderate effect size (ES: -.71) were linked to a training frequency of more than once per week, indicating that more frequent

training sessions correlate with better results. In contrast, the current SRMA did not observe significant improvements based on the duration of the training period, under-scoring that the frequency of training sessions may exert a more pronounced effect than the total duration of the training program.

These results highlight the need to design and implement specific training programs tailored to the unique needs of soccer players to optimize sprint performance. The effectiveness of interventions, such as the combination of short sprint exercises and plyometric training, emphasizes the importance of taking a personalized approach in sports training to maximize the benefits on sprint performance.

CODS time

The study findings significantly reveal that a reduction in CODS time (ES: -1.60, $P < .0001$) emphasizes the effectiveness of this type of training in improving CODS, a critical element for performance. The moderate heterogeneity between studies ($I^2 = 53\%$, $P = .07$) indicates that, although the results are broadly consistent, variations are likely to arise from differences in training implementation, participant characteristics or CODS evaluation methods. However, the marked improvement in CODS performance in the combined training groups, compared to the control groups (ES: -.84, $P < .00001$), with low heterogeneity ($I^2 = 29\%$), suggests that specific combined training is a powerful strategy to increase agility in youth soccer players.

Previous studies corroborate these findings and show that both short sprint training and cross-training can significantly improve CODS in team sports^{34,35}. Bedoya et al. have shown that plyometric and sprint training can improve performance in CODS tests in young athletes³⁶, which is consistent with the reduction in CODS time observed in this analysis. Additionally, the inclusion of CODS training and short sprints has been shown to be effective in reinforcing key physical skills crucial to soccer performance, such as sprint speed and the ability to make quick and efficient CODS^{34,35}.

These results underscore the importance of integrating short sprint exercises focused on improving CODS ability into training programs for adolescent soccer players to optimize their performance during the game. Furthermore, interventions with a training frequency of one session per week and two or more sessions per week produced a moderate effect, with ES of -1.13 and -.72, respectively. This suggests that both low and high frequency training programs are beneficial, and that the frequency of training sessions plays a vital role in achieving the desired results. Additionally, the duration of the interventions influenced the results: interventions lasting less than six weeks and those lasting six weeks or longer showed a small effect. The higher level of heterogeneity observed in subgroups with higher training frequency, period duration, and level is an important consideration, indicating that variations in these characteristics could affect the effectiveness of combined interventions.

Therefore, this SRMA shows that combined interventions are generally effective across youth populations and exercise characteristics. Consistency in results between different subgroups is good, although the observed heterogeneity underlines the complexity of these interventions and the need for personalized approaches.

Vertical jump performance

The inclusion of short sprint training significantly improved vertical jump height, with a moderate effect size (ES: .45; $P = .004$) and without heterogeneity between studies ($I^2 = 0\%$), indicating a positive effect. A comparison between the combined training groups and the control groups showed an even more substantial improvement in vertical jump performance, with a large effect

size (ES: 1.37, $P < .00001$), suggesting that integrating short sprint training with plyometrics, strength exercises or CODS is highly beneficial.

This multifaceted approach to training, which emphasizes CODS and explosive power, is crucial for soccer, where explosive actions such as jumping, sprinting and quick CODS are essential^{37,38}. The study findings support the idea that a combination of training types, designed to improve specific physical attributes, can significantly improve performance in young players.

Regarding the impact of population and exercise characteristics on the effectiveness of interventions, significant improvements were observed in highly trained groups, although with a modest effect size (ES: .49), indicating that even players with Advanced training may benefit from these interventions, although the effects are less pronounced compared to less experienced groups. The study also highlights the importance of frequency and duration of training, with interventions of more than one session per week and lasting 6 weeks or more showing significant improvements. This suggests that both consistency and duration of training are critical factors in achieving positive results.

The present study demonstrates the effectiveness of combined training interventions to improve vertical jump height and, therefore, performance in adolescent soccer players. It underlines the importance of a personalized and multifaceted training approach³⁹, considering the training level of the players and the specific physical demands of soccer. Future research should aim to explore the complex interaction between different training components and how they contribute to physical performance, with the aim of developing optimized training strategies for young athletes.

The present SRMA has several limitations. First, from a methodological point of view, a key limitation lies in focusing exclusively on adolescent male soccer players. Although this specificity is useful for detailed research, it limits the generalizability of the results to other populations, such as female soccer players or athletes of different ages and skill levels. Second, in terms of study variables, although multiple aspects of physical performance (such as linear sprinting, CODS, and jumping ability) were assessed, other dimensions of soccer performance were not included. For example, aspects such as endurance, coordination, and technical ability are also crucial for soccer performance but were not considered in this analysis. In addition, variability in the types of training (plyometric, strength or multidirectional) and the lack of standardization in the duration and frequency of these exercises could have influenced the results, making direct comparison between studies difficult. This variability in training protocols suggests that conclusions regarding the effectiveness of additional short sprints may not be universally applicable to all training regimens. In addition, most of the studies included in this meta-analysis focused on short-term interventions. Therefore, the long-term impact of additional short sprint training on the physical performance of young players cannot be determined with certainty. The lack of information on long-term effects is a significant limitation, as athletic development in adolescents often requires a long-term approach. Finally, although the current SRMA provides valuable information on the effects of additional short sprint training in young soccer players, its results should be interpreted with caution because of the aforementioned limitations. Further research is required to address these limitations and expand knowledge in this area.

Practical Applications

- Integrating short sprints with plyometric exercises in training programs can effectively enhance linear sprint performance, CODS, and vertical jump ability in youth male soccer players. This combined approach optimizes the development of key physical attributes necessary for soccer, such as acceleration, CODS, and explosive power.
- Strength and conditioning professionals should consider implementing training programs with a frequency of more than once per week, as this has been shown to produce significant improvements in sprint performance and CODS. While the total duration of the training period did not significantly affect outcomes, consistent and frequent sessions appear important for achieving the best results.
- Tailoring training programs to the individual needs of athletes is essential. The effectiveness of interventions such as combined short sprints and plyometrics suggests that a personalized approach, which considers the specific physical demands of soccer and the training level of the players, can maximize performance gains.
- The observed variability in training outcomes among more skilled subgroups suggests that training effectiveness may vary based on individual characteristics such as skill level and training experience. Therefore, coaches and physical trainers should consider these factors when designing and implementing training programs to ensure the interventions are appropriately challenging and beneficial.

Conclusions

The main findings revealed significant improvements in linear sprint times within the experimental groups compared to controls, highlighting the effectiveness of strength and speed training in improving sprint performance. Despite the lack of significant overall improvement in sprint times, specific interventions, particularly those combining short sprints and plyometric training, showed significant benefits, suggesting the importance of varied training modalities. A significant reduction in CODS time was observed, indicating the effectiveness of cross-training in improving CODS, a critical aspect of performance. This was supported by studies showing that short sprint training, when integrated with plyometric exercises, strength exercises or CODS exercises, can significantly improve vertical jump height and overall physical performance. The current SRMA highlights the role of training frequency, with more frequent sessions linked to better results, although the length of the training period did not significantly affect improvements. This suggests the value of consistent and prolonged training to achieve desired results. The analysis also points to a higher level of heterogeneity in outcomes among more skilled subgroups, indicating that the effectiveness of interventions may vary depending on individual characteristics. Finally, future research should further explore the synergies between different training components to develop optimized strategies to improve physical performance in young soccer players.

Ethical Committee approval

PROSPERO, the prospective international register of systematic reviews was used to register the protocol (CRD42024503692).

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Conflicts of interest

The authors have no conflicts of interest to declare.

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Author-s contribution

Conceptualization, E.P.-M. and H.N.; methodology, E.P.-M., H.N. and O.K.; writing—original draft preparation, O.K. and R.O.; writing—review and editing, E.P.-M., O.K., R.O. and H.N.; supervision, O.K. and R.O.; All authors have read and agreed to the published version of the manuscript.

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