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REVIEW

Improving change of direction in male football players through plyometric training: a systematic review

Jose Jimenez-Iglesias[1,2] · Adam L. Owen[3,4] · Carolina Cruz-Leon[1,2] · Miguel Angel Campos-Vázquez[5] · Sandra Sanchez-Parente[1,2] · Oliver Gonzalo-Skok[6] · Magdalena Cuenca-Garcia[1,2] · Jose Castro-Piñero[1,2]

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Abstract

Background High-intensity actions have gained increasing significance in contemporary football. Among these actions, the spotlight shines on the enhancement of change of direction (COD) speed. Several training methods have been employed to elevate this skill in football players, with plyometric training (PT) being one of the viable approaches. The objective of this review is to identify the diverse variables crucial for implementing an optimal PT regimen aimed at enhancing COD speed in football players.

Design A systematic examination was conducted involving previously published original experimental studies featuring control groups, the utilization of PT as a training modality, and the evaluation of one or multiple instances of COD in football players.

Method A systematic search was conducted on March 13, 2023, encompassing the MEDLINE, SPORTDiscus, and Web of Science databases. The quest was aimed at locating studies that incorporated control groups, adopted PT as a training methodology, and measured one or multiple COD scenarios, with studies being published in either English or Spanish.

Results A total of 34 studies were encompassed in this systematic review. Remarkably, with the exception of one, all the studies exhibited enhancements in COD performance through qualitative assessments when employing PT. It appears that PT, when used in isolation, is not outperformed by PT combined with another training method in the context of enhancing COD speed, provided that the overall training load remains unchanged.

Conclusion To improve COD speed in football players, a PT program spanning 6–9 weeks, featuring two weekly sessions with a 48 to 72-h rest interval between sessions, is advisable. The program should include 1–6 exercises that incorporate both unilateral and bilateral executions across various planes, performed at maximum intensity. Additionally, rest intervals between sets should range from 60 to 90 s, and the number of contacts should be increased by 60–200.

Keywords Athletic training · Interval training · Plyometric training · Football (soccer) · Biomechanics · Proprioception

✉ Carolina Cruz-Leon
carolina.cruz@uca.es

1 GALENO Research Group, Department of Physical Education, Faculty of Education Sciences, University of Cádiz, Cádiz, Spain

2 Instituto de Investigación e Innovación Biomédica de Cádiz (INiBICA), Cádiz, Spain

3 Inter-University Laboratory of Human Movement Biology, University Claude Bernard Lyon 1, University of Lyon, Lyon, France

4 International Soccer Science & Performance Federation (ISSPF), London, England

5 Faculty of Sport, Pablo de Olavide University, Seville, Spain

6 Department of Communication and Education, Universidad Loyola Andalucía, Seville, Spain

Introduction

In most team sports, successful performance hinges on the execution of rapid and explosive movements, such as sprinting, jumping, or changing direction [1]. Numerous studies have indicated a close association between sporting proficiency in these high-intensity actions and overall performance excellence [2].

Football, as a sport, is no exception to this paradigm. It is characterized by the frequent occurrence of high-intensity actions that hold pivotal significance within the game [3]. Furthermore, it is noteworthy that football has evolved in recent years into an increasingly intermittent form of play, featuring a heightened frequency of explosive actions [4, 5].

Approximately 12% of the total distance covered by players during a match involves these explosive actions [6]. Additionally, it is imperative to underscore that football is a multiplanar sport, wherein high-intensity actions like sprints, accelerations, or decelerations transpire within a three-dimensional context. Consequently, a football player must possess the capacity to execute explosive actions combined with changes of direction (COD), an aspect of paramount importance in enhancing a player's performance [3, 7–9]. In fact, a COD is typically executed every 2–4 s [10]. Moreover, it is essential to recognize that COD and sprint actions rank as the most decisive manoeuvres in the course of a match, serving as the most frequently observed actions leading to goals, both by the goal scorer and the assisting player [11]. Therefore, the optimization of the ability to perform high-intensity actions, with a specific emphasis on COD, should be a paramount concern for contemporary football players.

The ability to change direction should be distinguished from agility. While the former pertains to a pre-planned action, agility encompasses the capacity to execute motor actions in response to unanticipated stimuli, thus encompassing determinants that extend beyond physical and technical abilities, including cognitive aspects [7, 12]. Several effective methods have been identified for enhancing change of direction (COD) in football players. These methods encompass eccentric overload training [8], traditional strength training [13–15], sprint agility and quickness (SAQ) training [4, 16], small-sided games [17–20], complex training [21, 22], and plyometric training (PT) [9, 23–27]. Notably, PT holds particular promise for enhancing COD ability for various reasons [28]. PT is deemed a valuable strategy due to its potential to boost the speed of force application by stimulating the stretch–shortening cycle (SSC) [29], along with enhancing neuromuscular control and knee stability [28, 30]. Additionally, PT contributes to positive changes in muscle architecture, muscle–tendon mechanical stiffness, and an increase in neural drive [31]. These combined effects render PT an intriguing method for enhancing COD.

Despite an extensive body of literature linking PT to improved COD in football players, the optimal workloads and intensities of PT for maximizing COD benefits remain undetermined. Consequently, the objective of this review is to identify the appropriate training variables, including volume, intensity, and frequency, required to design an effective PT regimen for football players with the goal of enhancing COD ability.

Methods

In the present review, the Preferred Reporting Items for Systematic review and Meta-Analyses (PRISMA) guidelines were followed for the applied methodology [32].

Literature search

The search encompassed three distinct electronic scientific databases: MEDLINE (via PubMed), SPORTDiscus, and Web of Science, spanning from their inception until March 13, 2023. The screening of studies that employed PT to enhance COD performance in male football players was conducted by reviewers. Across all three databases, the search descriptors were categorized into three blocks: one block was dedicated to football, another focused on COD, and the third block pertained to PT (refer to supplementary material 1). Figure 1 provides a visual representation of the comprehensive search process.

Eligibility criteria

The inclusion criteria for this systematic review were (1) age criterion: all age ranges were included; participants (2): the study population was based on football male players. (3) study design: original experimental studies with control group were included; (4) intervention: Plyometrics must have been one of the training methods used; (5) measurements: One or multiple COD must have been measured in the experimental design with the appropriate devices (automated electronic machine, such as timing gates or a radar gun, or by a manual method such as a

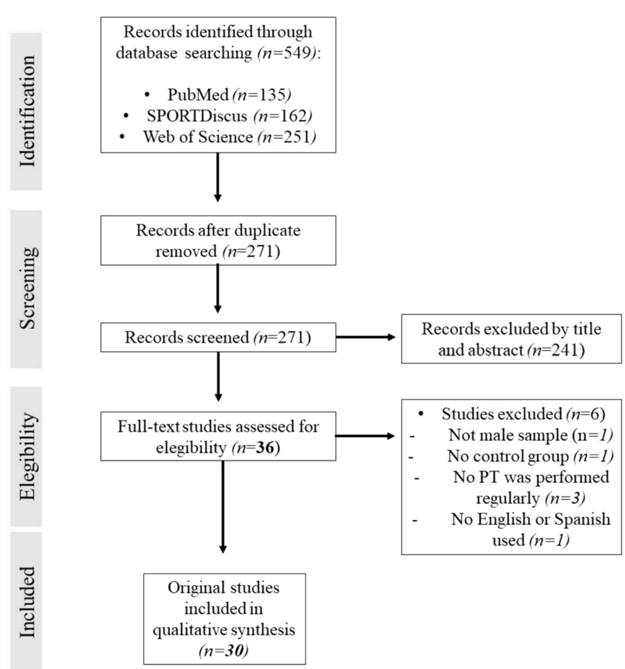

Fig. 1 PRISMA flowchart for selection of original studies and systematic reviews

stopwatch); (6) language criterion: articles only published in English or Spanish.

Study selection

Titles and abstracts of the studies selected were independently and assessed by two researchers (JJI and CCL) to determine their eligibility. After this, the same two researchers reviewed the full text of all the selected articles to decide which were included in the review according to the established criteria. The overall agreement between the reviewers was 99.2% (kappa = 0.988). When no consensus was reached between both researchers, a third researcher would make the final decision about inclusion, but it wasn´t necessary.

Data extraction

Researchers (JJI and CCL) then independently extracted the following information from each eligible original study according to standardized form: (1) author´s name; (2) participants (number and performance level); (3) age of participants (years); (4) study duration (weeks); (5) total sessions (number); (6) sessions per week (number); (7) rest between sessions (hours); (8) rest between sets (seconds); (9) contacts per sessions (number); (10) jump training characteristics; (11) number of exercises performed; (12) other training program (Table 1).

Criteria for risk of bias assessment

The assessment of bias risk (Table 2) involved two investigators, JJI and CCL, who conducted independent evaluations and scoring of the studies using the PEDro scale (Physiotherapy Evidence Database). This scale comprises 11 items and is specifically crafted for appraising the methodological quality of studies (5). The collective agreement between the two reviewers reached 98.6% (kappa = 0.976). In cases where consensus was not attained between the two researchers, a third researcher (JCP) was called upon to make the ultimate determination.

Statistical analysis

All the studies incorporated in this analysis conducted quantitative assessments with significance levels set at $p < 0.1$, $p < 0.05$, and $p < 0.01$ in their respective statistical methodologies.

For the calculation of changes in COD performance from pre- to post-training, a manual computation was performed using Microsoft Excel (Microsoft, Redmond, WA, USA) for each study. The following formula, consistent with previous reviews [33], was employed:

$$\%change = \left(\frac{\overline{X}post - \overline{X}pre}{\overline{X}pre}\right)X100$$

Each study also included the manual calculation of the effect size (ES) using Microsoft Excel (Microsoft, Redmon, WA, USA). The following formula [34] was used where $\overline{X}pre$ = mean pre-training sprint performance, $\overline{X}post$ = mean post-training sprint performance and $SDpre$ = Standard deviation pre-training sprint performance.

$$ES = \left(\frac{\overline{X}post - \overline{X}pre}{SDpre}\right)$$

ES was interpreted as trivial < 0.2, small for ≥ 0.2 ≤ 0.59, moderate for > 0.6 ≤ 1.19, large for > 1.20 ≤ 1.99, very large for > 2.0 ≤ 3.99 and extremely large ≥ 4.00 [35].

Results

The search yielded 561 studies. After removing duplicates, 298 studies remained, of which 258 were eliminated after reading the title and abstract. A total of 34 [23, 27, 29, 36–66] studies were included in the review after meeting the established inclusion criteria (Fig. 1). All the studies included had a score ranked of 4 or higher by PEDro scale. Most of them presented a score of 6–7 (Table 2).

Characteristic of the studies

The characteristics of the included studies are shown in Table 1. The observed changes in COD ability within and between groups after the training intervention are shown in Tables 3 and 4, respectively. All the included studies [23, 27, 29, 37–47, 49, 50, 52–61, 63–66] were original experimental designs with control group, 26 [23, 27, 36, 38, 40, 41, 45–53, 55–65] of which randomized the sample. All the studies employed the PT in isolation or in conjunction with other training methods, analyzed differences in COD performance pre- post- intervention, and employed a quantitative statistical analysis.

Characteristics of the sample

A total of 20 studies were conducted with amateur football players [23, 27, 29, 36, 39, 41, 42, 44, 47, 48, 50–53, 56, 58–61, 63, 64, 67], 11 employed professionals [37, 38, 40, 45, 46, 51, 54, 55, 57, 65, 66] and 3 studies [48, 49, 62] did not indicate the competitive level of the sample. The majority of the studies (28 in total) were conducted with

Table 1 Characteristics of the studies

Author	Participants (*n*)	Age, mean (*n*)	Study duration (weeks)	Total sessions (*n*)	SPW (*n*)	RBS (hours)	RBST (*s*)	CPS (*n*)	Jump training characteristics	NEP (*n*)	Other training
Hernández y García, 2013	Young amateur soccer players (49)	17.2	8	16	2	–	120	80	Bilateral, vertical loaded jumps and box jumps (40–50–60 cm)	2	Power clean strength training
Shamshuddin et al. 2020	Amateur soccer players (22)	21.5	6	12	2	–	180	120	Bilateral, vertical CMJ, unilateral, vertical side jump, and, bilateral, horizontal bounds	3	MNT
Sohnlein et al. 2014	Professional young soccer players (19)	12.3	16	32	2	72	–	56–175	Bilateral, lateral bounds, unilateral, horizontal hops, unilateral, lateral hop	2	MNT
Brito et al. 2014	Professional soccer players (57)	20.2	9	18	2	–	–	20–40	Bilateral, vertical jumps, unilateral, horizontal skipping	1	MNT
Ramírez-Campillo et al. 2015	Professional young soccer players (57)	11.2	6	12	2	–	–	110–220	Cyclic/acyclic, bilateral, vertical/horizontal CMJ (G1) Cyclic/acyclic, unilateral, vertical/horizontal CMJ (G2) Cyclic/acyclic, unilateral/bilateral, vertical/horizontal CMJ (G3)	1	MNT
Ramírez-Campillo et al. 2014a	Amateur young soccer players (76)	13.2	7	14	2	48	90	60	Bilateral, vertical drop jumps (20–40–60 cm)	1	MNT

Table 1 (continued)

Author	Participants (*n*)	Age, mean (*n*)	Study duration (weeks)	Total sessions (*n*)	SPW (*n*)	RBS (hours)	RBST (*s*)	CPS (*n*)	Jump training characteristics	NEP (*n*)	Other training
Ramírez-Campillo et al. 2014b	Amateur young soccer players (54)	10.1	7	14	2	48	30	60	Cyclic, bilateral, vertical drop jumps (20–40–60 cm), 30 s R (G1)	1	MNT
							60		Cyclic, bilateral, vertical drop jumps (20–40–60 cm) 60 s R (G2)		
							90		Cyclic, bilateral, vertical drop jumps (20–40-60 cm) 120 s R (G3)		
Negra et al. 2018	Amateur young soccer players (24)	12.7	8	16	2	72	90	50–120	Bilateral, Horizontal CMJ	1	MNT
Ramírez-Campillo et al. 2014c	Amateur young soccer players (40)	11.4	6	12	2	48	60	80–180	Cyclic/acyclic, bilateral/unilateral, vertical CMJ (G1)	2	MNT
									Cyclic/acyclic, bilateral/unilateral, horizontal CMJ and long jump (G2)		
									Cyclic/acyclic, bilateral/unilateral, vertical/horizontal CMJ and long jump (G3)		
Ramírez-Campillo et al. 2013	Amateur young soccer players (166)	14	6	12	2	24 (G1) 48 (G2)	120	140–260	Cyclic/acyclic, bilateral/unilateral, vertical/horizontal CMJ, cyclic, bilateral, vertical drop jumps (20 cm)	2	MNT

Table 1 (continued)

Author	Participants (*n*)	Age, mean (*n*)	Study duration (weeks)	Total sessions (*n*)	SPW (*n*)	RBS (hours)	RBST (*s*)	CPS (*n*)	Jump training characteristics	NEP (*n*)	Other training
Siskova et al. 2021	Amateur young soccer players (30)	10	6	12	2	–	60	60	Bilateral, vertical jumps over obstacles (25 cm) and bilateral, vertical ankle rebounds	2	Agility COD training
Vaczi et al. 2013	Amateur soccer players (24)	21.9	6	12	2	48	–	40–100	Bilateral, vertical jumps over obstacles (55–90 cm), unilateral, vertical/lateral jumps over obstacles (35 cm), bilateral, vertical drop jumps (55 cm)	3	MNT
Negra et al. 2016	Amateur young soccer players (28)	15.8	8	16	2	48	–	35–70	Bilateral, vertical jumps over obstacles (60 cm) and bilateral, vertical drop jumps (70 cm)	2	MNT
Ramírez-Campillo et al. 2018a	Amateur young soccer players (78)	10–16	7	14	2	–	90	60	Cyclic, bilateral, vertical drop jumps (20–40–60 cm)	1	MNT
Sáez de Villarreal et al. 2015	Professional young soccer players (26)	15.1	9	18	2	–	–	60–200	Bilateral, vertical jumps, cyclic, unilateral, horizontal skipping, bilateral, vertical drop jumps squat and jump, unilateral, horizontal stride jump, sidelong and 2° triple	6	MNT

Table 1 (continued)

Author	Participants (*n*)	Age, mean (*n*)	Study duration (weeks)	Total sessions (*n*)	SPW (*n*)	RBS (hours)	RBST (*s*)	CPS (*n*)	Jump training characteristics	NEP (*n*)	Other training
Kargarfard et al. 2020	Amateur young soccer players (24)	17.7	6	6 (G1)	1	–	30–120	33–63	Bilateral, horizontal long jumps, unilateral, horizontal long jumps, bilateral, vertical jumps, Unilateral, vertical long jumps	4	Sprint and COD training
Ramírez-Campillo et al. 2014d	Amateur young soccer players (24)	12.9	6	12	2	48	60	120 (G1) 120–240 (G2)	Cyclic/acyclic, bilateral/unilateral, vertical/horizontal CMJ and cyclic/acyclic, bilateral/unilateral, vertical long jumps	2	MNT
Drouzas et al. 2020	Professional young soccer players (105)	10	10	18	2	48	1:5	60–120	Bilateral, vertical/lateral jumps over obstacles (10–15–20 cm), bilateral, diagonal jumps, bilateral, lateral ladder jumps, bilateral, vertical jumps on a balance mat (G1) The same as G1 but unilateral (G2)	4	MNT

Table 1 (continued)

Author	Participants (*n*)	Age, mean (*n*)	Study duration (weeks)	Total sessions (*n*)	SPW (*n*)	RBS (hours)	RBST (*s*)	CPS (*n*)	Jump training characteristics	NEP (*n*)	Other training
Jlid et al. 2020	Amateur soccer players (27)	19	6	12	2	48	60	140–216	Unilateral alternating vertical/horizontal/lateral jumps, unilateral alternating vertical/horizontal/lateral jumps over obstacles (50 cm), bilateral, vertical squat jumps (50 cm) + drop jump (30 cm), Bilateral, vertical squat jumps (50 cm) vertical/horizontal/lateral jumps, bilateral vertical/horizontal/lateral jumps, Bilateral, vertical bench jumps (30 cm), unilateral, lateral/horizontal jumps over obstacles (45 cm)	9	MNT
Faude et al. 2013	Amateur soccer players (16)	22.5	7	14	2	48	240	20–22	Unilateral, horizontal jumps, bilateral vertical/lateral jumps, bilateral horizontal bound jumps, bilateral vertical drop jumps	6	Strength and sprint training
Hammami et al. 2018	Professional young soccer players (40)	15.8	8	16	2	48	–	35–70	Bilateral vertical jumps over obstacles (50–60 cm), bilateral vertical drop jumps (60–70 cm)	3	MNT

Table 1 (continued)

Author	Participants (*n*)	Age, mean (*n*)	Study duration (weeks)	Total sessions (*n*)	SPW (*n*)	RBS (hours)	RBST (*s*)	CPS (*n*)	Jump training characteristics	NEP (*n*)	Other training
Makhlouf et al. 2018	Professional young soccer players (57)	11	8	16	2	–	20	40–150	Bilateral vertical CMJ, bilateral vertical drop jumps (20 cm), bilateral horizontal/lateral jumps, unilateral, horizontal skipping, bilateral vertical ankle hops, unilateral vertical hops	6	Balance training (G1) Agility training (G2)
Manouras et al. 2016	Amateur young soccer players (57)	19.9	8	8	1	–	60–120	60–110	Bilateral vertical CMJ, bilateral vertical ankle jumps, bilateral vertical jumps over obstacles, bilateral vertical drop jumps (40 cm)	4	MNT
									Bilateral horizontal/diagonal long jumps, Bilateral diagonal jumps over obstacles, bilateral vertical ankle jumps	3	
Meylan et al. 2009	Young soccer players (57)	13.2	8	16	2	48	90	32–192	Bilateral vertical ankle jumps, bilateral vertical/lateral jumps over obstacles (20 cm), bilateral horizontal/lateral bounds, unilateral, horizontal skipping	4	MNT

Table 1 (continued)

Author	Participants (*n*)	Age, mean (*n*)	Study duration (weeks)	Total sessions (*n*)	SPW (*n*)	RBS (hours)	RBST (*s*)	CPS (*n*)	Jump training characteristics	NEP (*n*)	Other training
Michailidis et al. 2018	Amateur young soccer players (33)	12	6	12	2	72	–	100–200	Bilateral vertical/horizontal jumps, unilateral vertical/horizontal jumps	2	COD training
Jlid et el. 2019	Amateur young soccer players (28)	11.7	8	16	2	48	–	54–124	Unilateral alternating vertical/horizontal/lateral jumps, unilateral alternating vertical/horizontal/lateral jumps with feet together, bilateral vertical jumps over obstacles (30 cm), bilateral lateral jumps over obstacles (20 cm)	6	MNT
Negra et al. 2016	Amateur young soccer players (34)	12.8	12	24	2	72	120	112–280	Bilateral vertical ankle jumps, bilateral vertical jumps over obstacles, bilateral, vertical CMJ, bilateral lateral jumps over obstacles, bilateral lateral bounds, unilateral lateral zig–zag	6	MNT
Otero-Esquina et al. 2017	Professional young soccer players (36)	17	7	7 (G1) 14 (G2)	1 (G1) 2 (G2)	–	60	12–24	Bilateral vertical box jump (85–100 cm), bilateral vertical drop jump (40–70 cm), bilateral horizontal jumps over obstacles (50 cm)	4	FBS, plyometric, YoYo^{tm} leg-curl, RST

Table 1 (continued)

Author	Participants (*n*)	Age, mean (*n*)	Study duration (weeks)	Total sessions (*n*)	SPW (*n*)	RBS (hours)	RBST (*s*)	CPS (*n*)	Jump training characteristics	NEP (*n*)	Other training
Ramírez-Campillo et al. 2018b	Professional young soccer players (38)	17	7	14	2	72–96	30–60	104–204	Cyclic/acyclic bilateral horizontal/vertical bounds, bilateral, vertical multi-jumps, wall jumps, CMJ and tuck jumps, unilateral horizontal hops, unilateral lateral clock jumps and crossover hops, unilateral vertical lunge jumps	9	MNT
Keiner et al. 2020	Professional young soccer players (48)	17,45	40	80	2	–	300	18–24	Bilateral vertical drop jump, bilateral, vertical CMJ, bilateral horizontal broad jumps, bilateral horizontal triple jumps	5	RST, Sprint training and COD training

CMJ counter movement jump, *COD* change of direction, *CPS* contacts per session, *FBS* full-back squat, *G1* group 1, *G2* group 2, *G3* group 3, *MNT* maintained normal trained, *NEP* number of exercises performed, *RST* resisted sprint training, *R* rest, *RBS* rest between sessions, RBST rest between sets, *S* seconds, *SPW* sessions per week

Table 2 PEDro scale scores of critically reviewed articles (32)

Study	Items											Total score
	1	2	3	4	5	6	7	8	9	10	11	
Ramírez-Campillo et al. 2014 (d)	Yes	No	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Drouzas et al. 2020	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Faude et al. 2013	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Hammami et al. 2018	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Michailidis et al. 2018	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Ramírez-Campillo et al. 2013	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Ramírez-Campillo et al. 2014(c)	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Ramírez-Campillo et al. 2014(a)	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Ramírez-Campillo et al. 2015	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Ramírez-Campillo et al. 2018(b)	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Ramírez-Campillo et al. 2018(a)	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Ramírez-Campillo et al. 2014(b)	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Shamshuddin et al. 2020	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Sáez de Villareal et al. 2015	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Kargarfard et al. 2020	No	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Brito et al. 2014	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Jlid et el. 2019	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Jlid et al. 2020	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Keiner et al. 2020	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Makhlouf et al. 2018	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Manouras et al. 2016	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Negra et al. 2018	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Negra et al. 2016(a)	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Negra et al. 2016(b)	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Hernández & García, 2013	No	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	5
Vaczi et al. 2013	No	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	5
Meylan et al. 2009	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	4
Otero-Esquina et al. 2017	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	4
Siskova et al. 2021	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	4
Sohnlein et al. 2014	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	4

young players (mean age of 13.5 ± 2.5 years old) [23, 36, 38, 41–46, 48–62, 64–67], while the remaining 6 used adult players (mean age of 20.8 ± 1.3 years old) [27, 29, 37, 39, 47, 63]. Of the 28 studies that used young players, 18 studies included players younger than 15 years old [23, 36, 38, 43, 46, 49, 50, 52, 53, 56–62, 64, 65].

Characteristics of training intervention

A total of 23 [23, 27, 29, 37, 38, 40, 41, 43, 47, 49, 52, 53, 55–63, 65, 66] studies employed PT in isolation in their interventions, whereas the remaining 11 studies performed PT in addition to other training methods [36, 39, 42, 44–46, 48, 50, 51, 54, 64].

Regarding the duration of the training programs, 11 studies used 6 weeks [27, 29, 44, 50, 51, 57–59, 61, 63, 64], 10 extended 8 weeks [36, 40–43, 46–49, 52], 6 used 7 weeks [23, 39, 54–56, 60], 5 performed between 9 and 12 weeks [37, 38, 53, 62, 66], a single study used 16 weeks [65] and another one 40 weeks [45]. The number of sessions per week used in the interventions was 2 in all the studies [23, 27, 29, 36–43, 45, 46, 48–53, 55–66], with the exception of 2 that expended 1 [44, 47], and one that carried out both 1 and 2 sessions depending on the experimental group [54]. The total number of sessions that took place was 12 in 10 studies [27, 29, 50, 51, 57–59, 61, 63, 64], 16 in 9 studies [36, 40–43, 46, 48, 49, 52], 14 in 6 studies [23, 39, 54–56, 60], between 18 and 24 in 5 studies [37, 38, 53, 62, 66], 32 in a single study [77, 80 sessions in another study [45], and between 6 and 8 in 2 studies [44, 47].

In terms of training volume, all the studies used contacts per session (CPS) to quantify training load. Eleven studies used a volume of less than 70 CPS [23, 37, 39–41, 44, 45, 54, 56, 60, 64], 11 carried out between 40 and 175

Table 3 Changes in change of direction performance within group

Study	COD performance variable	ΔCOD performance (%)	Effect Size *(Cohen´s d)*	Effect Size rating
Hernández y García, 2013	TCOD30T (v)	0.76**	0.19	Trivial
Shamshuddin et al. 2020	ATT (t)	−2.33**	−3.75	Very large
Sohnlein et al. 2014	HAR (t)	−6.08***	−0.89	Moderate
Brito et al. 2014	ATT (t)	1.98	–	–
Ramírez-Campillo et al. 2015	FCOD10T (t)	G1 —0.3**	−0.42	Small
		G2 —8.3***	−0.80	Moderate
		G3 —8.3***	−0.66	Moderate
Ramírez-Campillo et al. 2014a	IAT (t)	−3.5***	−0.26	Small
Ramírez-Campillo et al. 2014b	LRT (t)	G1—6.5*	−1.03	Moderate
		G2—5.2*	−0.87	Moderate
		G3—6.9*	−1.04	Moderate
Negra et al. 2018	ATT (t)	−7.2*	1.6	Large
Ramírez-Campillo et al. 2014c	FCOD10T (t)	G1—2.5	−0.43	Small
		G2—1.9	−0.21	Small
		G3—5.1**	−0.70	Moderate
Ramírez-Campillo et al. 2013	10-5AT (t)	G1—5.6***	−0.52	Small
		G2—5.1***	−0.51	Small
Siskova et al. 2021	PAT (t)	−1.6**	−0.29	Small
Vaczi et al. 2013	ATT (t)	−2.47**	−0.32	Small
	IAT (t)	−1.69**	−0.72	Moderate
Negra et al. 2016	S180 (t)	−4.68	−0.95	Moderate
	SBF (t)	−0.43	−1.41	Large
	S4X5 (t)	−3.02	−0.76	Moderate
Ramírez-Campillo et al. 2018a	IAT (t)	−3.05***	−0.27	Small
Sáez de Villarreal et al. 2015	FCOD10T (t)	−7.9**	−1.10	Moderate
Kargarfard et al. 2020	505CODT	G1—4.2*	−0.94	Moderate
		G2—5.0*	−0.97	Moderate
Ramírez-Campillo et al. 2014d	ATT (t)	G1—7.6***	−0.43	Small
		G2—9.0***	−0.84	Moderate
Drouzas et al. 2020	ATT (t)	G1—1.7***	−0.31	Small
		G2—1.15***	−0.22	Small
Jlid et al. 2020	ATT (t)	−2.99***	−0.66	Moderate
Faude et al. 2013	SSDT (t)	−4.1*	−0.47	Moderate
Hammami et al. 2018	S4X5 (t)	−3.36**	−0.91	Moderate
Makhlouf et al. 2018	IAT (t)	G1—2.58**	−0.58	Small
		G2—3.16**	−0.95	Moderate
	4-9SRT (t)	G1—4.38	−0.92	Moderate
		G2—4.68	−1.63	Large
Manouras et al. 2016	IAT (t)	G1 −3.7	(RS) —1.51	Large
		−2.51	(LS) —0.91	Moderate
		G2 −3.5	(RS) —1.5	Large
		−2.78	(LS) —0.88	Moderate
Meylan et al. 2009	FCOD10T (t)	−9.6***	−2.81	Very large
Michailidis et al. 2018	ATT (t)	−3.1**	–	–
Jlid et el. 2019	ATT (t)	−3.07**	−0.5	Small
Negra et al. 2016	IAT (t)	−2.21***	−0.71	Moderate
Otero-Esquina et al. 2017	VCT	G1—2.25*	−0.75	Moderate
		G2—5.2*	−0.8	Moderate

Table 3 (continued)

Study	COD performance variable	ΔCOD performance (%)	Effect Size *(Cohen´s d)*	Effect Size rating
Ramírez-Campillo et al. 2018b	IAT (t)	G1—4.2**	−0.95	Moderate
		G2—0.7**	−0.25	Small
Keiner et al. 2020	TCOD10T	−0.31	−0.1	Trivial

ATT agility t test, *COD* change of direction, *ES* effect size, *FCOD10T* four changes of direction (60°) in 10 m test, *G1* group 1, *G2* group 2, *G3* group 3, *HAR* hurdle agility run, *IAT* Illinois agility test, *LRT* L-run test, *LS* left side, *PAT* pro-agility test, *RS* right side, *SBF* sprint backward and forward running, *SSDT* shuttle sprint and dribble test, *S4X5* sprint 4 × 5 m (90°–180° COD), *S180* sprint with 180° turns, *t* time, *TCOD10T* two changes of direction (60°) in 10 m test, *TCOD30T* three changes of direction (45°) in 30 m test; *V* velocity, *VCT* v-cut test, *10-5AT* 10–5 agility test, *505CODT* 505 change of direction test, *4-9SRT* 4 × 9 m shuttle run test. Significance difference found between pre- and post- testing within group (**p* < 0.1; ***p* < 0.05; ****p* < 0.01). ES was interpreted as trivial < 0.2, small from ≥ 0.2 to ≤ 0.59, moderate from > 0.6 to ≤ 1.19, large from > 1.20 to ≤ 1.99, very large from > 2.0 to ≤ 3.99 and extremely large ≥ 4.0 (Hopkins et al., 2009)

CPS [27, 38, 42, 43, 46, 47, 50, 52, 59, 63, 65], 8 used a volume of between 60 and 220 CPS [29, 36, 48, 51, 55, 57, 58, 66], 4 developed between 110 and 280 CPS [53, 59, 61, 62] and a single study [49] established a different range of CPS being between 32 and 192 CPS. As for the intensity, all the studies performed the plyometric exercises at maximum intensity [23, 27, 38–41, 45–47, 50, 52, 53, 55–62, 64, 65]. Twelve studies [29, 36, 37, 42–44, 48, 49, 51, 54, 63, 66] did not provide information on this variable.

The studies used different numbers of plyometric exercises, 13 used between 4 and 6 exercises [36, 38, 39, 43–49, 53, 54, 66], 9 performed 2 different exercises [41, 42, 50, 58, 59, 61, 62, 64, 65], 6 carry out one exercise [23, 37, 52, 56, 57, 60], 5 used 3 exercises [27, 40, 51, 63] and 2 achieved 9 exercises [29, 55].

The rest between these sessions was 48 h in 12 studies [27, 29, 38–41, 43, 49, 56, 58–60] and 72 h in 4 [50, 52, 53, 65]. One study used 48 h or 24 h depending on the experimental group [64, and 3 studies used between 72 and 96 h [51, 55, 62]. The rest of the studies did not provide information on these variables [23, 36, 37, 40, 42–45, 47, 48, 50, 57, 63, 64, 66].

Rest between sets/exercises was between 60 and 120 s in 17 studies [23, 29, 36, 42, 47, 49, 50, 52–54, 56, 58–62, 64], less than 60 s in 3 studies [46, 55, 56], other 3 studies [39, 45, 63] rested more than 120 s, one study [44] used between 30 and 120 s, and another one established recovery time with a ratio of 1:5 [38]. Ten studies did not provide information on recovery time [27, 37, 40, 41, 43, 50, 51, 57, 65, 66].

Regarding the characteristics of the exercises, 21 studies [27, 29, 36, 37, 39, 40, 43, 44, 46, 48–50, 53, 55, 57–59, 61, 63, 65, 66] used unilateral, bilateral and multi-planar work, 5 studies performed bilateral and multi-planar exercises [38, 45, 47, 54, 57], 8 of them executed bilateral and single plane exercises [23, 41, 42, 47, 52, 56, 60, 64], 2 studies carried out unilateral and multi-plane exercises [38, 57], two studies used bilateral and unilateral exercises in a single plane [58, 62] and a single study did not provided such information [51].

Changes in COD performance

Changes in COD ability were verified through the variable of test execution time in all the studies, except for one of them [42] that recorded the speed of displacement.

Within intervention/experimental group analysis (Table 3), all the studies found significant improvements in COD ability after the interventions, except four of them [37, 41, 45, 47]. These improvements were significant, with confidence levels of 90% in 5 studies [39, 44, 52, 54, 56], 95% in 14 studies [27, 40, 42, 43, 46, 48, 50, 51, 55, 57, 58, 63, 64, 66], and 99% in 12 studies [23, 29, 36, 38, 49, 53, 57, 59–62, 65]. The largest significant changes observed in COD performance were 9.6% ($p < 0.01$, ES:−2.81, very large) [49] and the smallest significant were 0.76% ($p < 0.05$, ES: 0.19, trivial) [42].

In reference to the improvements experienced as a function of the training variables, 29 studies [23, 27, 29, 36, 37, 39–44, 46–52, 54–61, 63, 64, 66] employed between 6 and 9 weeks with improvements between 0.7 and 9.6% (all $p < 0.1$, ES:0.19–2.81), and other 5 studies [38, 45, 53, 62, 65] employed more than 10 weeks with improvements between −1.13 and 6.8% (all $p < 0.1$, ES: −0.22–0.89).

The *number of sessions* employed was 2 weekly in 31 studies [23, 27, 29, 36–43, 45, 46, 48–53, 55–66] with improvements between 0.7 and 9.6% (all $p < 0.1$, ES: 0.19–2.81). While 3 studies [44, 47, 54] developed one weekly session with improvements between 2.25 and 5% (all $p < 0.1$, ES: −0.75–0.97).

The *number of exercises* used was between 1 and 3 in 20 studies [23, 27, 37, 40–42, 49–52, 56–65], with

Table 4 Changes in change of direction performance between groups

Study	Involved groups	COD performance variable (*m*)	Differences between groups^{D}
Hernández y García, 2013	EG: power clean + PT CG	TCOD30T (V)	ndf
Shamshuddin et al. 2020	EG: PT CG	ATT (t)	**EG** vs CG**
Sohnlein et al. 2014	EG: PT CG	HAR (t)	**EG** vs CG***
Brito et al. 2014	EG: PT CG	ATT (t)	ndf
Ramírez-Campillo et al. 2015	EG1: PT unilateral EG2: PT bilateral EG3: PT combined CG	FCOD10T (t)	**EG2** vs CG** **EG3** vs CG**
Ramírez-Campillo et al. 2014a	EG: PT CG	IAT (t)	**EG** vs CG**
Ramírez-Campillo et al. 2014b	EG1: PT 30 s rest EG2: PT 60 s rest EG3: PT 120 s rest CG	LRT (t)	**EG1** vs CG** **EG2** vs CG** **EG3** vs CG**
Negra et al. 2018	EG: PT CG	ATT (t)	**EG** vs CG*
Ramírez-Campillo et al. 2014c	EG1: PT vertical EG2: PT horizontal EG3: PT combined CG	FCOD10T (t)	**EG3** vs CG**
Ramírez-Campillo et al. 2013	EG1: PT 24 h rest EG2: PT 48 h rest CG	10-5AT (t)	**EG1** vs CG*** **EG2** vs CG**
Siskova et al. 2021	EG1: agility COD training EG2: PT + agility COD training CG	PAT (t)	**EG2** vs CG**
Vaczi et al. 2013	EG: PT CG	ATT (t) IAT (t)	**EG** vs CG** **EG** vs CG**
Negra et al. 2016	EG: PT CG	S180 (t) SBF (t) S4X5 (t)	ndf
Ramírez-Campillo et al. 2018a	EG: PT CG	IAT (t)	**EG** vs CG**
Sáez de Villarreal et al. 2015	EG: PT + specific soccer drills (acceleration, dribbling and shooting) CG	FCOD10T (t)	**EG** vs CG***
Kargarfard et al. 2020	EG1: PT and Sprint and COD training same day EG2: PT and Sprint and COD training separate day CG	505CODT	**EG1** vs CG* **EG2** vs CG* EG1 vs **EG2***
Ramírez-Campillo et al. 2014d	EG1: PT non-progressive volume EG2: PT progressive volume CG	ATT (t)	ndf
Drouzas et al. 2020	EG1: PT unilateral EG2: PT bilateral CG	ATT (t)	ndf
Jlid et al. 2020	EG: multidirectional PT CG	ATT	**EG** vs CG***
Faude et al. 2013	EG: PT, sprint and strength training CG	SSDT (t)	ndf

Table 4 (continued)

Study	Involved groups	COD performance variable (*m*)	Differences between groups^D
Hammami et al. 2018	EG1: PT EG2: contrast training CG	S4X5 (t)	**EG1** vs CG** **EG2** vs CG**
Makhlouf et al. 2018	EG1: PT + agility training EG2: PT + balance training CG	IAT (t)	**EG1** vs CG** **EG2** vs CG**
		4-9SRT (t)	**EG1** vs CG** **EG2** vs CG**
Manouras et al. 2016	EG1: PT vertical EG2: PT horizontal/diagonal CG	IAT (t)	ndf
Meylan et al. 2009	EG: PT CG	FCOD10T (t)	**EG** vs CG**
Michailidis et al. 2018	EG: PT + COD training CG	ATT (t)	ndf
Jlid et el. 2019	EG: multidirectional PT CG	ATT (t)	**EG** vs CG**
Negra et al. 2016	EG1: PT EG2: strength training CG	IAT (t)	**EG1** vs CG*** **EG2** vs CG***
Otero-Esquina et al. 2017	EG1: PT and strength 1-day frequency EG2: PT and strength training 2 days' frequency CG	VCT	**EG1** vs CG* **EG2** vs CG* EGI vs **EG2***
Ramírez-Campillo et al. 2018b	EG1: PT before soccer practice EG2: PT after soccer practice CG	IAT (t)	EG1 vs **EG2**** **EG2** vs CG**
Keiner et al. 2020	EG1: PT and Sprint training EG2: functional training group EG3: traditional strength CG	TCOD10T	**EG1** vs CG**

ATT agility t test, *COD* change of direction, *ES* effect size, *FCOD10T* four changes of direction (60°) in 10 m test, *G1* group 1, *G2* group 2, *G3* group 3, *HAR* hurdle agility run, *IAT* Illinois agility test, *LRT* L-run test, *LS* left side, *PAT* pro-agility test, *RS* right side, *SBF* sprint backward and forward running, *SSDT* shuttle sprint and dribble test, *S4X5* sprint 4 × 5 m (90°–180° COD), *S180* sprint with 180° turns, *t* time, *TCOD10T* two changes of direction (60°) in 10 m test, *TCOD30T* three changes of direction (45°) in 30 m test; *V* velocity, *VCT* v-cut test, *10-5AT* 10–5 agility test, *505CODT* 505 change of direction test, *4-9SRT* 4 × 9 m shuttle run test. Significance difference found between pre- and post- testing. Significance difference found between pre- and post- testing between groups (*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$).

^Unclear, If the chances of having better and poorer results were both > 5%.

Bold words, indicates the group in which the performance improvements occurred compared to the other group. *D*: the results presented in this column are those that showed some type of interaction, either positive or negative; if the comparison between certain groups in a study is not the same, it is because no interaction was shown

improvements between 0.7 and 9% (all $p < 0.1$, ES: 0.19–0.84). Thirteen studies [36, 38, 39, 43–49, 53, 54, 66] used between 4 and 6 exercises with improvements between 0.31 and 9.6% (all $p < 0.1$, ES: 0.1–2.81). Only 2 studies [29, 55] employed 9 exercises, with improvements between 2.99 and 4.2% (all $p < 0.01$, ES: 0.66–0.95).

Regarding the number of *CPS*, 28 studies [23, 27, 29, 36, 38, 40–43, 46–53, 55–61, 63–66] employed between 60 and 200 CPS, with improvements between 0.7 and 9.6% (all $p < 0.1$, ES: 0.19–2.81). Another 3 studies [39, 44, 54] employed around less than 60 CPS with improvements between 4.1 and 5.2% (all $p < 0.1$, ES:−0.48–0.8).

The intensity at which the exercises were performed was maximal in the 22 studies [23, 27, 38–41, 45–47, 50, 52, 53, 55–62, 64, 65] that provided this data, with improvements of between and 1.6 and 9% ($p < 0.1$, ES:0.29–0.84).

Thirteen studies used 48 h *of recovery between sessions* [27, 29, 38–41, 43, 49, 56, 58–61] found improvements of between 1.17% and 9.6% (all $p < 0.1$, ES:0.31–2.81). Another 7 studies [50–53, 55, 62, 65] used 72 h or more of recovery found improvements of between 2.21% and 7.2% (all $p < 0.1$, ES:0.71–1.6). Finally a single study [61] used 24 h of recovery between sessions found improvements of 5.1% ($p < 0.01$, ES: −0.52).

The *rest time used between sets* was variable, using less than 60 s in 3 studies [46, 55, 56]. One of them performed rest of 30 s with improvements of 6.5% ($p < 0.1$, ES: −1.03) [56], another one included rest between 30 and 60 s with improvements of 4.2% ($p < 0.05$, ES: −0.95) [55] and the last one achieved only rest of 20 s with improvements of 3.16% ($p < 0.05$, ES: −0.95) [46]. On the contrary, 14 studies [23, 29, 36, 38, 48, 49, 52, 54, 56, 58–60, 62, 64] used rests between 60 and 90 s, with improvements between 1.16 and 9.6% (all $p < 0.1$, ES:−0.29–2.81). Finally, 6 studies [42, 45, 47, 53, 61, 63] established recoveries of more than 90 s, with improvements between 0.76 and 5.6% (all $p < 0.1$, ES:0.19–0.52).

Twenty-four studies [27, 29, 36–39, 43, 44, 46–49, 53–59, 61, 63, 65, 66] used multiple planes of movement, with improvements between 1.15 and 9.6% (all $p < 0.1$, ES:0.22–2.81). The remaining 8 studies used a single plane with improvements between 0.76 and 7.2% (all $p < 0.1$, ES:0.19–1.6), only one study did not provided information [51].

Regarding the *execution regime*, 20 studies [27, 29, 36, 37, 39, 43, 44, 46, 48–50, 53, 55, 57–61, 63, 65, 66] combined bilateral and unilateral movement execution, with improvements between 2.21 and 9.6% (all $p < 0.1$, ES:0.71–2.81); and 2 study employed only bilateral work with improvements between 0.76 and 7.2% (all $p < 0.1$, ES:0.19–1.6).

Concerning the between-group analysis (Table 4), all studies [23, 27, 29, 36–66] performed the effect on an experimental group of training that included plyometrics versus a control group. Twenty-one of these studies [23, 27, 29, 37, 38, 40, 41, 43, 46, 47, 49, 52, 53, 56–61, 63, 65] compared PT with the control group and 16 of them [23, 27, 29, 40, 43, 46, 49, 52, 53, 56–58, 60, 61, 63, 65] found significant improvements (all $p < 0.1$). In contrast, a total of 11 studies [36, 42, 44–46, 50, 51, 54, 64, 68, 69] compared the effect of a PT combined with other training methods versus the control group, of which 8 studies [36, 44–46, 51, 54, 64, 69] found significant improvements (all $p > 0.1$).

On the other hand, 18 studies [38, 40, 44–48, 53–59, 61, 62, 64, 66] compared experimental groups. Eight of them [38, 47, 55–59, 61] compared groups that performed plyometric training with different training variables. None of them obtained significant differences between groups ($p \leq 0.1$), with the exception of one study [55], which suggested that PT seems to report greater improvements when performed at the beginning of training than at the end ($p < 0.5$). The other nine studies [40, 44–46, 53, 54, 62, 64, 66] compared groups that included an isolated PT or with another training method, versus another experimental group with another training methodology. Only two studies obtained significant improvements; one of them [54] determining that PT is superior with a frequency of 2 days than one ($p < 0.1$); and the other of them [64] showed that PT added to COD and agility training, obtained greater improvements than when PT were not used in addition to agility and COD training ($p < 0.5$).

Discussion

The aim of this study was to establish an appropriate plyometric training (PT) protocol for optimizing change of direction (COD) performance in male football players. The primary findings indicate that PT is an effective approach for enhancing COD performance within this population. A PT regimen spanning 6–9 weeks with two sessions weekly, separated by 48–72 h of rest, accompanied by an increase in contacts per second (CPS) ranging from 60 to 200, incorporating 1–6 exercises that encompass both unilateral and bilateral executions performed at maximal intensity, and with rest intervals between sets of at least 30 s (with optimal improvements observed at rest intervals between 60 and 90 s), appears to be ideal for enhancing COD in football players. Additionally, it was observed that when PT is combined with strength training, reducing the volume of the latter seems necessary to attain greater improvements.

General considerations

The compilation of studies within this review clearly demonstrates how PT yields significant enhancements in COD performance among male football players. These findings align with previous reviews conducted in various team sports populations [28]. Furthermore, other reviews in the realm of football have likewise indicated that PT appears to have a positive impact on enhancing other athletic aspects, such as jumping and sprinting [70, 71].

Existing literature suggests several reasons underlying the positive effects of PT on COD performance, primarily related to enhancements in strength, power, and stability [28, 29]. Firstly, it is worth noting that PT reduces ground contact time, which is crucial in COD movements requiring swift transitions from eccentric (braking) to concentric phases [28, 72, 73]. These reductions in contact time stem from the stimulation of the stretch–shortening cycle (SSC) in muscle–tendon units. The improvement in SSC optimizes neural drive in agonist musculature, diminishes action time in antagonist musculature, and enhances tendon stiffness [31, 74]. Furthermore, PT contributes to improvements in eccentric muscle actions, facilitating quicker deceleration during COD maneuvers [7]. Additionally, PT enhances postural adjustments by increasing balance and stability, particularly in the knee joint [28, 30, 75, 76]. Structural improvements, such as alterations in muscle size, muscle architecture, and single fiber mechanics, also play a role [31]. All these factors collectively augment the reactive force index and movement efficiency, ultimately optimizing COD ability [28, 29, 57].

Volume and intensity variables of the PT interventions

In regard to variables associated with volume, there are several noteworthy aspects to consider. It appears that a PT duration spanning 6–9 weeks, involving a total of 12–18 sessions, is sufficient to elicit significant enhancements in COD ability among football players. These findings align with results from other reviews examining the impact of PT on sprinting ability and vertical jump in young football players [71]. Similarly, another review that assessed the effect of PT on COD ability across athletes from various sports arrived at a similar conclusion [28]. However, Bedoya et al. (2015) suggested a requirement of 8–10 weeks to achieve greater benefits in various components of a football player's physical fitness. Nevertheless, in our study, interventions exceeding 8 weeks did not yield greater improvements than those adhering to a 6–9-week protocol. The timeframe of 6–9 weeks and 12–18 sessions may be explained by a review and meta-analysis [71] that found programs of more than 7 weeks and more than 14 sessions to be more effective in enhancing linear sprinting compared to interventions of shorter duration. However, when evaluating vertical jumping, longer programs did not surpass shorter ones, possibly due to the delayed acquisition of improvements in horizontal force application compared to vertical force application [11, 71]. Given that COD performance relies significantly on both horizontal and vertical force application [77], the optimal duration for improvements appears to be between 6 and 9 weeks. It is proposed that improvements in COD around the 6-week mark may be attributed to enhanced vertical force application, while those near 8–9 weeks depend on factors, including improved horizontal force application. The observation that periods exceeding 9 weeks did not yield significant improvements, and in some cases even led to performance decrements [37], may be linked to mechanisms related to a decrease in tendon stiffness due to excessive exposure to the stretch–shortening cycle (SSC) and muscle fatigue, resulting in diminished performance in explosive actions [78].

Similarly, an excessive number of contacts per session (CPS), particularly exceeding 200, does not seem to generate substantial improvements in COD speed. Conversely, an insufficient volume, as observed in one study [37], fails to stimulate adequate adaptations. According to our findings, the optimal range for progress lies between 60 and 200 CPS. However, literature suggests that to enhance performance in explosive actions, reaching up to 120 CPS may be sufficient [70]. Nevertheless, it is worth noting that our review included only seven studies, with only three assessing the effect of PT on COD. Consequently, the conclusions drawn by these authors may lack sufficient consistency regarding the subject of our investigation. It was observed that when approximately 200 CPS were reached, improvements in COD appeared to be more significant [49, 58, 59, 61, 65, 66]. Notably, the most substantial improvements (9% [$p < 0.01$, ES: −0.84] and 9.6% [$p < 0.01$, ES: −2.81]) were recorded when the CPS volume approached 200.

Regarding the intensity and execution speed of exercises, maximum intensity and speed were consistently employed across interventions where information on these variables was provided [23, 27, 38–41, 45–47, 50, 52, 53, 55–61, 64, 65]. This aligns with expectations, as such intensity and speed are imperative to stimulate the stretch–shortening cycle (SSC) and optimize the benefits of plyometric training [31].

In terms of weekly PT frequency, it appears that two sessions per week yield the most significant benefits. Studies implementing a single weekly session [44, 47] did not achieve greater improvements than those employing two sessions. Otero-Esquina et al. [54] examined the impact of working 1 versus 2 days a week in a strength program that incorporated PT. They found that a frequency of 2 days led to more substantial improvements in COD skills (significant differences between groups with $p < 0.1$ in favor of the 2-day group) and other components of player explosiveness. It seems that a single training session per week is insufficient for inducing substantial adaptations, particularly among experienced athletes [54, 79]. Two reviews [28, 70] have established 72 h as the optimal rest period between PT sessions. However, our review suggests that the most significant improvements occur when participants rest between 48 and 72 h, resulting in enhancements ranging from 1.17% to 9.6% (all $p < 0.1$, ES: 0.31–2.81) [27, 29, 38–41, 43, 49, 56, 58–61]. Thus, it can be deduced that an optimal recovery time between PT sessions falls within the range of 48–72 h.

Another PT variable to consider is the rest period between exercise sets. Asadi et al. (2016) found no significant differences in the magnitude of rest between sets among diverse athlete populations when aiming to enhance COD. Similarly, in our review, although the most significant COD performance improvements appeared to occur with rest intervals between 60 and 90 s, we did not observe clear distinctions between longer or shorter rest intervals. Nevertheless, a minimum rest duration of 30 s appears to be necessary. Ramirez-Campillo et al. [56] investigated the differences between resting for 30, 60, or 120 s, and while all groups improved their COD ability compared to controls, no significant differences were found among them. Although some literature posits that longer rest periods allow greater substrate recovery and enhance explosive actions [80], some authors contend that in young athletes, faster recovery of phosphagen, quicker elimination of metabolites, and the restoration of acid–base balance and maximal power occur in less time [81]. Given that our review primarily encompasses studies involving young football players, this may explain the absence of substantial differences between short and extended recovery times.

The nature of the exercises is another critical variable to consider. Studies that combined unilateral and bilateral exercises across different planes of movement consistently achieved better results compared to those that solely employed a single plane of movement or exclusively unilateral or bilateral exercises. Ramirez-Campillo et al. [57] demonstrated that the combination of bilateral and unilateral exercises led to superior COD speed improvements. Additionally, another study highlighted that incorporating multiplanar exercises in PT resulted in greater enhancements in COD compared to exclusively working within a single plane [58]. These findings are substantiated by the notion that COD necessitates the application of force both vertically and horizontally [77]. Furthermore, unilateral exercises closely approximate the transfer of COD and stimulate increased activity in the hamstrings, gluteus medius, and trunk [82, 83]. However, CODs demand both unilateral and bilateral force production [10], making the combination of both execution types optimal.

In terms of the number of exercises utilized, it appears that 1–6 plyometric exercises suffice, provided the CPS volume is adequate. No significant improvements were observed in programs incorporating a high number (> 6) of exercises. This may be attributed to the fact that a high number of exercises may divert attention toward mastering the technical aspects of all proposed exercises, rather than executing them with maximal control and explosiveness to elicit genuine SSC benefits [84]. Thus, it may be worthwhile to simplify training in this regard. Nevertheless, it is essential to maintain a sufficient number of exercises to increase the variability of stimuli to the player, promoting greater adaptability to competitive stimuli and subsequent performance enhancement [85].

Multicomponent training programs

In numerous studies, plyometric training (PT) was combined with other forms of training to enhance various aspects, including change of direction (COD) performance [39, 42, 44–46, 50, 54, 64]. It cannot be definitively stated that COD improvements are consistently higher when players are exposed to multicomponent training programs. In fact, in some studies where additional resistance training was incorporated [42, 54], COD improvements were marginal (0.76% [$p < 0.05$, ES: 0.19, trivial] and 2.25% [$p < 0.1$, ES: −0.95, moderate]), and in one case, no significant improvements were observed [45]. These modest gains may be attributed to excessive work volumes that can induce counterproductive fatigue [37, 86]. Additionally, a review combining PT with weightlifting reported slightly better improvements (4.1% [$p < 0.1$, ES: −0.47]), but with a lower volume. This suggests that the overall training volume is a significant factor to consider. It is also worth noting that stiffness is readily influenced and can be one of the early indicators of fatigue in football players [87], which can directly impact the stretch–shortening cycle (SSC) and explosive action performance [31]. When PT was integrated with technical COD training, varied outcomes emerged. One study reported modest improvements (1.16% [$p < 0.05$, ES: −0.29, small]), potentially due to the low volume of SSC work, exclusive use of bilateral jumps, and insufficient emphasis on unilateral exercises, which are crucial for COD enhancement.

However, Kargarfard et al. (2020), combining specific COD training and PT with a low CPS volume, achieved more substantial improvements (4.2% [$p < 0.1$, ES: −0.94, moderate]). This difference can be explained by the inclusion of both unilateral and bilateral exercises, along with specific sprint training, which is known to be highly beneficial for the posterior chain [88], a crucial musculature in the braking phase of CODs [8]. Michailidis et al. (2019) also obtained improvements (3.1% [$p < 0.05$]) through a combination of PT and specific COD training, likely due to a well-considered PT variable selection. Similarly, Makhlouf et al. (2018) reported similar performance increases by combining PT with agility training (3.16% [$p < 0.05$, ES: −0.95, moderate]).

Conclusions

The main conclusions of the present review were: (1) PT is an adequate method to improve COD in football players; (2) The ideal protocol seems to be to accumulate 2 weekly sessions for 6–9 weeks, resting between sessions between 48 and 72 h, progressing in a volume of 60 to 200 CPS, using 1 or 6 exercises with multi-plane, bilateral and unilateral exercises executed at maximum intensity; (3) The optimal rest between sets is unclear, but it appears that a minimum of 30 s should be considered and that the greatest improvements are obtained by resting between 60 and 90 s. (4) When PT is combined with strength training, it seems that to obtain greater improvements, it is necessary to reduce the training volume of this component in order not to achieve a total training volume that could generate excessive fatigue; (5) When PT is combined with agility and COD work, it is necessary to maintain the recommended training volume as well as the proposed execution variants if greater improvements want to be obtained.

Practical implications

Incorporating PT into training programs for soccer players is a practical and effective means of improving COD and should be considered. Apart from its evident benefits, PT is cost-effective and requires minimal time for development. To create a tailored PT protocol, it is essential to adapt the various variables outlined in this review to suit the individual characteristics of soccer players. Despite its advantages, PT should be integrated within a multifaceted training regimen that mirrors the realities of contemporary soccer training. Consequently, these variables should be adjusted in consideration of other training methods employed and the overall training volume load.

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Declarations

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