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Systematic Review

Effects of plyometric training on agility in male soccer players—a systematic review

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Abstract

Background: Plyometric training is used to improve human neuro-muscular function and performance in sports. Agility as a necessary motor ability, which is one of the physical components of success in many sports, is especially important for the optimal performance of soccer players. Due to changes in direction and movement during the game, soccer players shows the ability to quickly change direction, stop quickly and perform through fast, accurate, and precise repetitive movements. The aim of this study was to determine the effects of plyometric training on the agility in male soccer players, based on studies that have dealt with the effects of plyometric training. **Methods**: The search and analysis of the studies were done in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyzes (PRISMA) guidelines. A literature search of 4 databases (Google Scholar, PubMed, Web of Science and Research Gate) was conducted using all available studies by November 2021. The identified studies had to meet the following criteria: original longitudinal studies written in English, active male soccer players as sample of participants, experimental treatment of plyometric training with at least two groups of subjects, studies that covered the impact of plyometric training, and studies containing agility tests. **Results**: A total of 21 studies were included in the systematic review. Improvements in agility tests were small, moderate, and large and ranged from 2% to 14.63%. The greatest improvement in agility was shown in soccer players after a two-week and six-week plyometric program, where the agility test showed a significant improvement of 14.63%. Programs lasting six and eight weeks proved to be the most effective plyometric training program. Plyometric training related to jumps with a progressive increase in intensity and a series of exercises for activation of the lower extremities, there was an improvement of 0.41 s to 0.90 s. **Conclusions**: Based on the analysis of the included studies, it can be concluded that according to the duration of the program, the minimum period where there can be an improvement in agility and other motor skills is six weeks, and that the usual weekly load is two to three pieces of training.

Keywords: exercise; jump; change of direction; male football

1. Introduction

Soccer, as a typical intermittent sport, involves various explosive movements such as sprinting, jumping, changes in acceleration and direction of movement and agility [1], requires players to perform numerous actions that require agility, strength, speed, balance, stability, flexibility, and endurance [2–4] stating that the physical preparation of players is a very complex process. Therefore, one of the most important tasks of the training process in soccer is the improvement of specific strength, which could be defined as the ability of players to use muscle strength effectively when performing tasks characteristic of a soccer match [5]. Analyzes of time and movement have shown that soccer players, due to changes in direction and movement during the game, show the ability to quickly change direction, stop quickly and perform through fast, accurate, and precise repetitive movements [6] with proper posture [7].

Plyometric training is used to improve human neuro-muscular function and improve performance in sports in which explosive strength and endurance are expressed [8, 9]. Plyometric program as a specialized high-intensity training process used to develop motor skills [10,11] consists of exercises such as horizontal and vertical jumps, drop jump (DJ), countermovement jump (CMJ), hurdles [12–14]. Beside explosive power, agility as a necessary motor ability, which is one of the physical components of success in many sports, is especially important for the optimal performance of soccer players [15]. Several studies highlight the potential advantage of training processes in which plyometric training is applied [16–20].

In studies that investigated the impact of plyometric training [13], periodic programs that showed a positive impact on improving motor skills such as agility were applied. Jullien *et al*. [18] showed in the study that a short-term plyometric training program (lasting 3 weeks) improved the results of agility tests in young professional soccer players.

In previous years, plyometric training has been the subject of several studies that have confirmed its impact, as in the Michailidis *et al*. [19] study, where results showed that it has an impact on soccer players aged 10–11, also Diallo *et al*. [20] claim to affect the performance of soccer players aged 12–13, Matavulj *et al*. [21] in basketball players aged 15–16 and in young recreational players [22,23]. A study by Meylan & Malatesta [24] showed that an eight-week plyometric training program has a positive impact on explosive actions in younger soccer players. A meta-analytical review of the Markovic [25] confirmed the efficacy of plyometric training in the CMJ performance of men and women using common statistical methods; however, most of the included studies were conducted on male participants (83% of men versus 17% of women). Previous studies have concluded that the effectiveness of plyometric training depends on the volume and frequency of the program [26], as well as a number of subject characteristics, such as strength training level [27], gender [28], age [29], and sport [30,31].

To the authors knowledge, there are no systematic review about the effects of plyometric training on agility in soccer. This systematic review includes studies that have dealt with the application of plyometric exercise programs in soccer players. The studies also included agility tests (T agility test, Zig-zag Test, Illinois Agility test) which showed whether there was an improvement in the results after the applied programs. The significance of this research will be that provides information on the effects of the plyometric exercise program in soccer participants, ie what changes occur in the values of agility using plyometric training, based on a systematic review of studies that had the same or similar research goals. Hence, the aim of the research was to determine the effects of plyometric training on the agility in male soccer players, based on a systematic review of studies that have dealt with the application of plyometric training programs to soccer players.

2. Materials and methods

2.1 Literature identification

The review and analysis were performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyzes) guidelines [32, 33]. Searches were conducted in the following electronic databases: Google Scholar, PubMed, Web of Science, and Research Gate, using all available studies until November 2021. The following keywords were used to search for the articles reportig effects of plyometric training on agility in soccer players: (“exercise” or “training” or “plyometrics” or “explosive strength” or “explosivness” or “legs strength” and “soccer” or “soccer players” and “agility” or “movement”).

A descriptive method was used to analyze the data obtained, and all titles and abstracts were reviewed for possible study inclusion. At the same time, the identification strategy was modified and adapted to the particular database to increase the sensitivity. After a detailed identification process, studies were considered to be relevant if they met the inclusion criteria.

The search for studies, assessment of their value and data extraction were conducted independently by two authors (I.Č. and M.M.), and the lists of references from previously assessed and original research were also reviewed. After that, each author cross-examined the identified studies, which were then taken for further analysis or rejected.

2.2 Inclusion criteria of studies

The following criteria for inclusion are defined for the selection of studies included in the final analysis: original scientific studies, studies based on longitudinal design, studies written exclusively in English, sample of participants—active male soccer players, experimental treatment in the conditions of plyometric training at least two groups of subjects (one experimental—one control or two or more experimental), studies that covered the impact of plyometric training, and studies containing agility tests. Eligibility criteria were also presented in Table 1, according to the PICOS model for eligibility criteria (participant, intervention, control, outcome and study design).

2.3 Risk of bias assessment

The risk of bias was assessed according to the Physiotherapy Evidence Database to determine the quality of clinical trials (PEDro scale) [34]. Two independent reviewers (I.Č. and M.M.) assessed quality and risk of bias using checklists. Concordance between reviewers was estimated using k-statistics data to review the full text and assess relativity and risk of bias. In case of discordance as to findings of the risk of bias assessment, the obtained data were assessed by the third reviewer (A.P.), who also made the final decision. The k-rate of concordance between reviewers’ findings was k = 0.91.

2.4 Data extraction

After the cross-examination and only if the data were adequate, the information was extracted. The standardized data extraction protocol was applied (Cochrane Consumer and Communication Review Group’s) to extract the necessary characteristics, such as first author and year of publication, sample size, age, groups, experimental treatment (program duration and plyometric program), along with monitored agility variables as main outcomes measured and the results obtained.

3. Results

3.1 Quality of studies

Based on the points each study scored on the PEDro scale, the final quality assessment scores were defined. With a grand total of 0–3 points, studies were classified as “poor”; 4–5, “fair”; 6–8, “good”; and 9–10, “excellent” [23]. Of all studies included, only one study showed poor

Table 1. PICOS model of eligibility criteria.

	Inclusion	Exclusion
Population	Male soccer players, childen, adolescent, elite, sub-elite	Female soccer players Other sports participants Injured participants or participants returning from injuries
Intervention	Plyometric training	Strength training, flexibility training
Control	-	-
Outcome	Agility tests	
Study design	Randomised study Non-randomised study Pre-post study Treatment study	Case study, pilot study, systematic review, meta-analysis, rehabilitation, case reports, non-English studies

Table 2. PEDro scale results.

	Criterion											
Study	1	2	3	4	5	6	7	8	9	10	11	∑
Thomas, French & Hayes (2009) [29]	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Meylan & Malatesta (2009) [24]	Y	N	N	Y	N	N	Y	Y	Y	Y	Y	6
Váczi, *et al.* (2013) [35]	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	7
Cavaco, *et al.* (2014) [36]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
García-Pinillos, *et al.* (2014) [37]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Mathisen (2014) [38]	Y	N	N	Y	N	N	Y	Y	Y	Y	Y	6
Taheri, *et al.* (2014) [39]	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Ramirez, *et al.* (2014) [40]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Granacher, *et al.* (2015) [41]	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
Hammami, *et al.* (2016) [42]	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
de Hoyo, *et al.* (2016) [43]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Yanci, *et al.* (2016) [44]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Manouras, *et al.* (2016) [45]	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
Ari & Çolakoğlu (2017) [46]	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Negra, *et al.* (2017) [47]	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
Kobal, *et al.* (2017) [48]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Makhlouf, *et al.* (2018) [49]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Zouhal, *et al.* (2019) [50]	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Damasco & Greco (2020) [51]	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
Fiorilli, *et al.* (2020) [52]	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Padrón-Cabo, *et al.* (2021) [53]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9

Legend: 1—eligibility criteria; 2—random allocation; 3—concealed allocation; 4—baseline comparability; 5—blind subject; 6—blind clinician; 7—blind assessor; 8—adequate follow-up; 9—intention-to-treat analysis; 10—between-group analysis; 11—point estimates and variability; Y—criterion is satisfied; N—criterion is not satisfied; ∑—total awarded points.

quality, 13 studies showed fair quality, and the rest of 8 studies showed excellent quality, which is shown in the Table 2 (Ref. [24,29,35–53]).

3.1 Selection and characteristics of studies

A search of electronic databases and scaning the reference lists yielded 11,024 relevant studies. After removing the duplicates, a total of 3321 studies remained. Additional studies were excluded based on inclusion criteria and a total of 63 studies were screened and selected for eligibility. When the sensitivity was increased and in-deeper check, 42 studies with nonrelevant outcomes, lack of output data, various non-plyometric pieces of training were additionally excluded. In the end, a total of 21 full-text studies were included in the systematic review (Fig. 1).

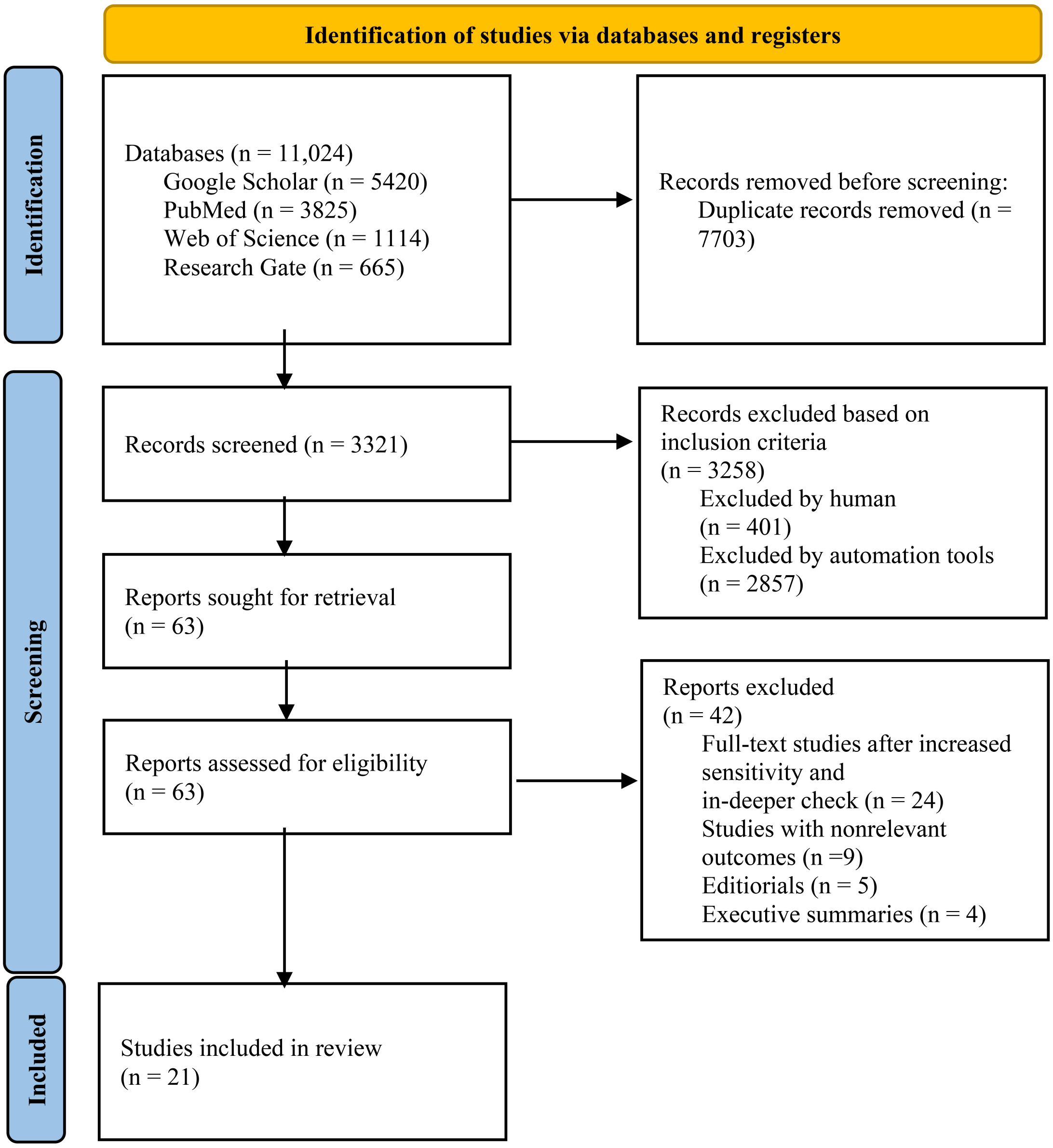

Fig. 1. Collectng adequate studies on the basis of pre-defined criteria (PRISMA flow chart).

Table 3 (Ref. [24,29,35–53]) shows the studies that met the set conditions and included in the qualitative analysis.

All studies that met the inclusion criteria were original scientific studies published in English between 2009 and February 2021. The total number of samples was 547 male subjects, where the largest number of subjects was in the study of Makhlouf *et al.* [49] and the smallest in the studies of Thomas, French & Hayes [29], 12 participants and Yanci *et al.* [44], 16 participants. The age of the participants ranged from 10 to 29 years. Plyometric training included exercises that were horizontal and vertical jumps [24,36,39,46,48,50,53], CMJ and DJ [29,35–37,39,41–44] and jumps with the use of props (ladder, cones, groin and obstacles). Plyometric training programs lasted 2 weeks [41,46], 6 weeks [36,37,43,47,48], 8 weeks [24,35,38–40,42,43,49–51], 10 weeks [45] and 12 weeks [44,52].

4. Discussion

The aim of this study was to determine the effects of plyometric training on the agility in male soccer players, based on studies that have dealt with the effects of plyometric training, while the main findings confirmed that the application of a plyometric program is effective for improving agility in male soccer players. Improvements in agility tests after application of the program are small, moderate, and large. The value of improving agility, on the one hand, can be influenced by the type of training or the age of the participants, showing a greater improvement in agility in younger compared to adult soccer players.

Table 3. Review of studies.

Author and year of publication	Sample of participants		Experimental treatment		Variables	C	%	E	%
	N	Groups and age (years)	Duration (weeks)	Plyometric program					
Thomas, French & Hayes (2009) [29]	12	DJ (n = 6) CMJ (n = 6) 17.3 ± 0.4	6 weeks 2× a week	DJ (40 cm), CMJ	505 AT	X	X	X	DJ 1.3% ↑ CMJ 1.5% ↑
Meylan & Malatesta (2009) [24]	25	E (n = 14) 13.3 ± 0.6 C (n = 11) 13.1 ± 0.6	8 weeks 2× a week	HJ, VJ, Lj, La	AT	Pre = 4.58 Post = 4.70	2.8% ↓	Pre = 4.69 Post = 4.24	9.6% ↑
Váczi *et al.* (2013) [35]	14	E (n = 12) 21.9 ± 1.7 C (n = 12) 22.7 ± 1.4	6 weeks	DJ, HJ, VJ, Lj	IAT TAT	IAT Pre = 15.83 Post = 15.62 TAT Pre = 11.87 Post = 11.98	1.33% ↑ 0.93% ↓	IAT Pre = 15.34 Post = 15.08 TAT Pre = 11.72 Post = 11.43	IAT 1.69% ↑ TAT 2.47% ↑
Cavaco *et al.* (2014) [36]	16	GCT1 (n = 5) 13.8 ± 0.84 GCT2 (n = 5) 14.2 ± 0.45 C (n = 6) 14.2 ± 0.84	2 weeks 3× times a week	Squat exercise	15 m AT with ball	Pre = 9.88 Post = 9.90	0.20% ↓	GCT1 Pre = 10.64 Post = 9.80 GCT2 Pre = 9.64 Post = 8.54	GCT1 7.89% ↑ GCT2 11.41 ↑
García-Pinillos *et al.* (2014) [37]	30	E (n = 17) 15.47 ± 1.28 C (n = 23) 16.38 ±1.5	12 weeks 3× a week	Jumping from a sitting position Jumping on one leg with the help of hands (with a change of leg)	BAT	Pre = 11.93 Post = 11.89	0.34% ↑	Pre = 12.29 Post = 11.66	5.13% ↑
Mathisen (2014) [38]	26	E (n = 14) 13.5 ± 0.24 C (n = 12) 13.5 ± 0.23	8 weeks	HJ,VJ, Jotg	AT	Pre = 8.25 Post = 8.18	0.85% ↑	Pre = 8.23 Post = 7.69	6.56% ↑
Taheri *et al.* (2014) [39]	30	E (n = 15) C (n = 15) 18–25	8 weeks 3× a week	X	4 × 9 AT	Pre = 10.55 Post = 10.50	0.47% ↑	Pre = 10.23 Post = 10.04	1.86% ↑

Table 3. Continued.

Author and year of publication	Sample of participants		Experimental treatment		Variables	C	%	E	%
	N	Groups and age (years)	Duration (weeks)	Plyometric program					
Ramirez *et al.* (2014) [40]	76	E (n = 38) C (n = 38) 10–16	7 weeks 2× a week	DJ (20 cm, 40 cm and 60 cm)	IAT	Pre = 20.1 Post = 20.8	3.5% ↓	Pre = 21.01 Post = 20.3	3.5% ↑
Granacher *et al.* (2015) [41]	24	SPT (n = 12) UPT (n = 12) 15	8 weeks 2× a week	CMJ, DJ	AT	UPT Pre = 8.56 Post = 8.32	2.9% ↑	SPT Pre = 8.56 Post = 8.29	3.1% ↑
Hammami *et al.* (2016) [42]	28	E (n = 15) 15.7 ± 0.2 C (n = 13) 15.8 ± 0.2	8 weeks 3 times a week	DJ, Jotg	4 × 5 m AT 9-3-6-3-9 m AT 180^o	4 × 5 m AT Pre = 6.21 Post = 6.23 9-3-6-3-9 m Pre = 8.56 Post = 8.67 AT 180^o Pre = 8.38 Post = 8.36	4 × 5 m AT 0.32% ↓ 9-3-6-3-9 m 1.05% ↓ AT 180^o 0.24% ↑	4 × 5 m AT Pre = 6.28 Post = 6.09 9-3-6-3-9 m Pre = 8.85 Post = 8.44 AT 180^o Pre = 8.75 Post = 8.34	4 × 5 m AT 3.03% ↑ 9-3-6-3-9 m 4.67% ↑ AT 180^o 4.69% ↑
de Hoyo *et al.* (2016) [43]	32	SQ (n = 11) rs (n = 13) PLYO (n = 9) 19	8 weeks 2× a week	Lj, 4-3-3 m ZZ	AT CMJ Speed	X	X	PLYO Pre = 4.94 Post = 4.94	PLYO AT 0.02% ↑ CMJ 0.50% ↑
Yanci *et al.* (2016) [44]	16	E1 (n = 8) 22.50 ± 5.04 E2 (n = 8) 24.63 ± 2.72	6 weeks 2× a week	CMJ, DJ	AT	X	X	E1 Pre = 4.92 Post = 4.86 E2 Pre = 4.87 Post = 4.87	E1 1.05% ↑ E2 0%
Manouras *et al.* (2016) [45]	30	HPG (n = 10) 19.10 ± 5.75 VPG (n = 10) 20.75 ± 6.14 C (n = 10) 20.00 ± 3.51	8 weeks 3× a week	DJ, HJ, VJ, CMJ, Fj, Dj	IAT (RS, LS)	RS Pre = 17.12 Post = 17.10 LS Pre = 17.12 Post = 17.13	0.12% ↑ 0.06% ↓	HPG RS Pre = 16.74 Post = 16.12 LS Pre = 16.73 Post = 16.31 VPG RS Pre = 17.14 Post = 16.54 LS Pre = 17.23 Post = 16.75	HPG RS = 3.74% ↑ LS = 2.51% ↑ VPG RS = 3.5% ↑ LS = 2.79% ↑

Table 3. Continued.

Author and year of publication	Sample of participants		Experimental treatment		Variables	C	%	E	%
	N	Groups and age (years)	Duration (weeks)	Plyometric program					
Ari & Çolakoğlu (2017) [46]	35	E (n = 15) 14.53 ± 0.83 C (n = 20) 14.40 ± 1.09	12 weeks 2× a week	HJ, VJ, ZZ, Rju, skipping cones and sprints, Lj, Dj, Joo, VJ, BX, DJ	HAT, ZZ	HAT Pre = 12.83 Post = 12.20 ZZ Pre = 7.25 Post = 7.31	HAT 4.91% ↑ ZZ 0.82% ↓	HAT Pre = 12.90 Post = 11.84 ZZ Pre = 7.55 Post = 6.99	HAT 8.21% ↑ ZZ 7.41% ↑
Negra *et al.* (2017) [47]	34	SPT (n = 18) 12.7 ± 0.2 UPT (n = 16) 12.2 ± 0.5	8 weeks 2× a week	VJ, HJ	IAT	X	X	UPT Pre = 18.25 Post = 16.81 SPT Pre = 16.31 Post = 16.40	UPT 7.89% ↑ SPT 0.55% ↓
Kobal *et al.* (2017) [48]	27	CP (n = 9) TD (n = 9) CT (n = 9) 18.9 ± 0.6	8 weeks 2× a week	BX (30 and 45 cm), DJ	505 AT	X	X	X	CP = 0.59% ↑ TD = 0.11% ↑ CT = 0.67% ↑
Makhlouf *et al.* (2018) [49]	57	BP (n = 21) AP (n = 20) C (n = 16) 10–12	8 weeks 2× a week	DJ, CMJ, HJ, Jotg, one-foot jumps over the cone with a change of direction	4 × 9 AT IAT with and without the ball	4 × 9 AT Pre = 10.43 Post = 10.36 IAT without Pre = 18.38 Post = 18.28 IAT with Pre = 25.22 Post = 24.40	C 4 × 9 AT 0.6% ↑ IAT without 0.6% ↑ IAT with 3.2% ↑	BP 4 × 9 AT Pre = 10.49 Post = 10.03 IAT without Pre = 18.16 Post = 17.69 IAT with Pre = 23.12 Post = 22.51 AP 4 × 9 AT Pre = 10.46 Post = 9.97 IAT without Pre = 18.00 Post = 17.43 IAT with Pre = 23.06 Post = 22.34	BP 4 × 9 AT 4.4% ↑ IAT without 2.5% ↑ IAT with 2.6% ↑ AP 4 × 9 AT 4.7% ↑ IAT without 3.1% ↑ IAT with 3.1% ↑

Table 3. Continued.

Author and year of publication	Sample of participants		Experimental treatment		Variables	C	%	E	%
	N	Groups and age (years)	Duration (weeks)	Plyometric program					
Zouhal *et al.* (2019) [50]	20	E (n = 10) 17.7 y C (n = 10) 16.8	6 weeks 2× a week	VJ, Lj	AT 180^{o}	Pre test = 1.46 Post test = 1.44	1.46% ↑	Pre = 1.45 Post = 1.38	4.83% ↑
Damasco & Greco (2020) [51]	31	E (n = 15) 28.8 ± 4.1 C (n = 16) 29.4 ± 2.4	10 weeks once a week	VJ, Joo, VJ, Lj, Dj, BX	TAT IAT	TAT Pre = 11.4 Post = 11.9 IAT Pre = 16.3 Post = 16.8	TAT 4.4% ↓ IAT 3.1% ↓	TAT Pre = 11.5 Post = 11 IAT Pre = 16.3 Post = 15.7	TAT 4.3% ↑ IAT 3.7% ↑
Fiorilli *et al.* (2020) [52]	34	FEO (n = 28) 13.21 PT (n = 16) 13.36	6 weeks 2× a week	DJ, BX, La	YAT IAT	YAT Pre = 2.80 Post = 2.72 IAT Pre = 23.07 Post = 22.12	YAT 2.86% ↑ IAT 4.07% ↑	YAT Pre = 2.87 Post = 2.67 IAT Pre = 22.08 Post = 18.85	YAT 9.06% ↑ IAT 14.63% ↑
Padrón-Cabo *et al.* (2021) [53]	20	E (n = 10) 12.60 ± 0.70 C (n = 10) 12.39 ± 0.56	6 weeks 2× a week	SJ, CMJ, CMJA	AT	AT Pre = 8.07 ± 0.36 Post = 8.03 ± 0.37	0.65% ↑	AT Pre = 7.99 ± 0.2 Post = 7.95 ± 0.4	0.65 ↑

Legend: E, experimental group; C, control group; X, no data; HJ, horizontal jump; VJ, vertical jump; SJ, squat jump; CMJ, countermovement jump; CMJA, countermovement jump with arm swing; HPG, horizontal plyometric group; VPG, vertical plyometric group; DJ, drop jump; IAT, Illinois agility test; YAT, Y-agility test; TAT, T-agility test; AT, agility test; CP, complex training; TD, traditional training; CT, contrast training; BAT, Balsom agility test; RS, right side; LS, left side; HAT, hexagon agility test; SPT, stable plyometric training; UPT, unstable plyometric training; AP, agility-plyometric group; BP, balance plyometric group; SQ, back squat group; PLYO, plyometric and speed-agility group; rs, resisted sprint group; PT, plyometric training group; FEO, flywheel eccentric overload group; GCT1, a group that performed once a week complex training; GCT2, a group that performed twice a week complex training; ZZ, zig-zag test; Lj, lateral jumps; Dj, diagonal jumps; Fj, frontal jumps; La, ladders; BX, box jump; Joo, jumping over obstacles; Jotg, jumping over the groin; Rju, rope jumping.

The most effective plyometric training program proved to be a program lasting six and eight weeks [24,29], which did CMJ, DJ, horizontal and vertical jumps twice a week. The T agility test and the Illinois Agility test were the most common tests done to assess agility. The frequency of plyometric training was one to three times a week. The greatest improvement in agility was shown in soccer players after an eight-week plyometric program in the study of Meylan & Malatesta [24], compared to Thomas *et al.* [29], where the agility test showed a significant improvement of 9.6%, which means that there was an improvement in values in the first and second groups (experimental), compared to the pre-test $p < 0.001$. The adaptations should be considered as neural, because in the early stages of training program, the strength and power training adaptations predominates [54,55]. Wilson *et al.* [56] have already explained that early explosive high-velocity training brings greater improvements in explosive actions, as well as in rate of force development.

In studies investigating the effects of plyometric training related to jumps with a progressive increase in intensity and a series of exercises to activate the lower extremities, there was an improvement of 0.41 s to 0.90 s [42,46,47,49,51]. Thomas, French & Hayes [29], Váczi *et al.* [35] and Yanci *et al.* [44] showed the effect of a six-week program, in which there was an improvement in the experimental group ($p < 0.05$), and agility increased by 1.7% to 9%. The results of seven studies [44–47,50,51,53] did not show a significant difference between the groups ($p > 0.05$), but there was an improvement in the experimental group after the application of the program. Studies by García-Pinillos *et al.* [37] and Mathisen [38] showed the influence of the plyometric program with combined isometric and plyometric exercises without external load, where there was an improvement of 5.13% and 6.6%, respectively. Ramirez-Campillo *et al.* [40] in their study, after applying a seven-week program, received a small but significant improvement in the experimental group (3.5%). Diversity of results could be explained by the fact that the effectiveness of plyometric training mostly depends on the volume and frequency [26], as well as strength training level [27], gender [28] and participants age [29]. The authors of the included studies recommend that the scope and intensity of plyometric training be adjusted periodically when determining the exercises to be done in the program. Coordination-demanding exercises lead to the development of agility [57]. It was found that there are different effects of plyometric training on agility, speed, and performance improvement in jumps used by CMJ and DJ, on reducing landing time and re-jumping, on reducing landing force, and increasing jump height [58,59].

The ability to change direction during running has been recognized as an important factor for successful participation in team sport [60,61], as well as in soccer [62]. When the training exercises match the task (e.g., testing, competitions), the effective transfer of training adaptations occurs [63]. Plyometric movements, such as jumping, hopping and bounding, performed quickly and explosively are related to development of agility, according to several authors [12–14]. In our case, differences were observed in the experimental group using running with a change of direction at angles of 60°, 90°, and 180°. Plyometric training from 20–30 min, which is done as part of a more complex soccer training lasting 90 min, has proven to be the best mechanism in plyometric programs. The dosage that leads to improved agility is the application of training twice a week, no more than four series. Such training of plyometrics, in which vertical and lateral jumps over the groin, as well as exercises with ladders, are performed, leads to the improvement of horizontal and vertical jump, improvement of lateral and linear agility [24]. Deep jumps are used in plyometric training to develop explosive leg strength. By jumping from a height, the muscles (eccentric phase) are stretched, which immediately reflexively (through stretching the muscle spindles) contract (concentric phase), which facilitates muscle contraction and thus improves explosive power [45]. Within one training session, soccer players who begin plyometric exercises perform 50 to 60 leg contacts while applying a plyometric training program to 110 to 120 leg contacts (in plyometrics, the amount of training is often measured by the number of leg contacts with the ground during jumps) [29,47]. Using the program, plyometric training was found to be a link between speed and strength [48].

The significance of this research is that it provides information on the impact of the plyometric exercise program in soccer participants, ie what changes occur in the values of agility using plyometric training, based on a systematic review of studies that had the same or similar research goals. Previous research contains the necessary information on the gender, age of the participants, the duration of the program and the intensity of exercise, and the effects achieved. Based on these data, the analysis of the results provided information on which program is best for improving agility in players, whether the achieved effects differ concerning the beginning of testing and after the applied plyometric training program.

This systematic review survey was limited to male soccer players only. In addition to all the advantages of the study, the limitation of the study is that the results can only be applied to men, the impact of the program was applied to only one sport and one motor ability. Future studies should extend these observations to women, to other sports, at various levels of competition, the impact of plyometric training on other motor skills, in recreational soccer players, the application of programs of different intensity, and comparison of these programs.

5. Conclusions

Plyometric training leads to an improvement in the soccer agility of soccer players by applying various programs of plyometric exercises. Programs of two, eight-week, ten-, and twelve-week lead to improved agility, while the six-week plyometric training program proved to be the best in terms of program duration and intensity. Our systematic review research provides evidence of the beneficial effects of plyometric exercise on agility in male soccer players of different ages. The application of the plyometric program leads to positive changes in the results of agility tests. Based on the analysis and discussion of the studies taken in the systematic research, it can be concluded that according to the duration of the program, the minimum period where agility and other motor skills can improve is six weeks and that the usual weekly load is two to three pieces of training per week. Analyzed studies have confirmed that this type of training is suitable for improving agility in players who apply plyometric training in addition to the main training. Plyometric training can contribute a lot, as a regular training program, to improving motor skills that are very important for players, such as agility. It's easy to organize, and there is a wide range of programs and exercises, as well as tests to assess agility.

The obtained results provide information that in practice can help coaches in determining the type, scope, and intensity of training, all to achieve the best results of agility as one of the most dominant motor skills. Also, the presented results can be a recommendation for further research dealing with plyometrics and the impact of plyometric training on agility in male soccer players.

Author contributions

IČ, MSt, MM, AP—conceptualization and writing; GS, NT—methodology; BD—software and validation; OŠ, MSp—formal analysis and resources; GS, BD—investigation; NT—data curation; DĐ—writing, original draft preparation, review and editing; BD, MSp, OŠ—visualization; GS—supervision; NT—project administration. All authors have read and agreed to the published version of the manuscript.

Ethics approval and consent to participate

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Conflict of interest

The authors declare no conflict of interest.

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