The efficacy of plyometric training on explosive actions (sprinting, jumping, agility and ball kicking) on the performance of young soccer players.

Isaak Alexandros Koutsoklenis

Biomedicine with Exercise Physiology application, 30 credits

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The efficacy of plyometric training on explosive actions (sprinting, jumping, agility and ball kicking) on the performance of young soccer players.

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School of Business, Engineering and Science

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Acknowledgements

The author would like to thank Professor Ann Bremander for her valuable and edifying assistance, suggestions, and advice for the completion of this review.

Abstract

**Background:** Plyometric training is a form of conditioning with increasing popularity that involves the performance of body weight jumping type exercises with the use of the stretch-shortening cycle muscle action. It is widely accepted that plyometric training has beneficial effects on many sports, including soccer. **Objectives:** To assess the effect of plyometric training on explosive actions of soccer performance (sprinting, jumping, agility, ball kicking) and indicated the kind, the frequency and targeted age groups on which the plyometrics should be executed. **Methods:** A search for all types of trials was performed on Pubmed, Web of Science and Sport Discus databases and the results were recorded according to PRISMA recommendations. 24 studies were included and judged for risk of bias and quality of evidence according to Cochrane guidelines and GRADE. **Results:** The studies were judges to have “low”, “high” and “unclear” risk of bias and were judged as “moderate”, “low” and very low quality of evidence. The finding of most of the studies show that plyometric training has beneficial effects and statistically significant improvements on the explosive actions (sprinting, jumping, agility and ball kicking) of young soccer players between 10 and 19 years old. **Conclusions:** The level of evidence of the review is moderate which means that further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate. The current study suggests that plyometric training can be beneficial for young soccer players when is applied with gradual intensity, frequency of 2-3 times per week and along with regular soccer and strength training. Future research of higher quality of evidence studies and lower risk of bias should be performed in this field. **Key words:** plyometric training, young soccer players, explosive actions
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Background

Soccer is one of the most popular sports worldwide. Approximately 200 million athletes of all ages, gender, and social status, both on amateur and professional level play soccer in clubs around the world (Longo et al, 2012). The popularity of soccer has inspired the sport science community to try and investigate and analyze the main characteristics of the sport and the factors that can affect the performance of a soccer player during the game. It is generally acknowledged that the parallel physical capacities of both technical skills with the ball and physical fitness is the key for a soccer player to achieve a successful performance in a soccer match (Little & Williams, 2005). A great level of soccer performance needs the successful skillfulness in abilities like the repeated explosive burst, strength, power, kicking, tackling, and their derivatives such as jumping, turning, sprinting, and changing direction speed (Ramirez et al, 2015).

Plyometric training is a form of conditioning with increasing popularity that involves the performance of body weight jumping type exercises with the use of the stretch-shortening cycle muscle action (Meylan and Malatesta, 2009). The stretch and shortening cycle improves the capacity of the neural and musculotendinous systems to produce the maximal amount of force in the shortest possible time, a fact that makes plyometric training a combination of power and speed (Markovic and Mikulic, 2010) According to Wang and Chang, 2016 plyometric training consists of dynamic and rapid stretching of muscles (eccentric action) that is instantly followed by a concentric of shortening action of the same muscles and connective tissues. The purpose of plyometric training is to increase the power of subsequent movements using both natural elastic components of muscle and tendon and the stretch reflex (Bedoya et al, 2015). The great advantage of plyometric training is that it uses the stored elastic energy of the muscles, something that cannot be produced by a concentric contraction alone (Wang and Chang, 2016). Plyometric training programmes typically include explosive exercises such as bounding, hopping and drop jumping and the shortest time of ground touch as it is followed by a rapid movement on the opposite vertical side (Wang and Chang, 2016). This kind of plyometric exercises is shown that can be beneficial for a variety of sports that require explosive actions like sprinting, jumping and change of direction speed. More specifically, a variety of studies (Michailidis et al 2013; Söhnelin, et al 2014; Loturco et al, 2015; Saez et al, 2015; De Hoyo et al,
2016) has shown plyometric training to be beneficial for the enhancement of performance of young soccer players on aspects like jumping, sprinting, kicking and agility. According to the studies of Behm et al, 2008 and Faigenbaum et al, 2009 the plyometric training can be beneficial for youth populations, when is applied according to particular guidelines in order to decrease the risk of injury. The benefits of plyometric training in young athletes consist of increase in neuromuscular function and enhanced bone density.

Systematic review

Systematic reviews seek to systematically search for, appraise and synthesize data from original research on a topic area by using a methodologically transparent and thus replicable process (Grant & Booth, 2009). It attempts to collate all empirical evidence that fits pre-specified eligibility criteria in order to answer a specific research question (Oxman & Guyatt, 1993). This systematic review was conducted according to the Cochrane Handbook for Systematic Reviews of Interventions (http://handbook-5-1.cochrane.org/) and the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-analyses) guidelines (Moher et al 2015).

An earlier systematic review of Bedoya et al, 2015 has studied the general effectiveness of plyometric training on soccer performance of young players. Except for the aforementioned review there are no other reviews in the scientific society that have dealt with these specific effects of plyometric training. This study adds the different fact that contributes to exactly these four specific aspects of soccer performance. Therefore, the purpose of this systematic review is to investigate the efficacy of plyometric training on sprinting, jumping, ball kicking and agility in particular on soccer players under 20 years old and show in which way the plyometric exercises can be applicable and beneficial for the young soccer players. This study adds the different fact that contributes to exactly these four specific aspects of performance.
Objectives

The main purpose of this systematic review is to assess the efficacy of plyometric training on several explosive actions such as sprinting, ball kicking and agility on the performance of young soccer players.

The research questions based on the above purpose are the following:

1. Does plyometric training as a part of the soccer training have a positive effect on the performance of young soccer players on particular explosive actions such as sprinting, jumping, ball kicking and agility?

2. What kind of exercises of plyometric training, in which frequency and intensity, and in which specific age groups should plyometric exercises be used in the soccer training in order to have a positive effect on the performance of young soccer players?

Methods

Criteria for considering studies for this review

Type of studies

The type of studies that were included in this review were the Randomized control trials (RCT), the Experimental studies with control group (EC), Experimental studies with one group only (E). Grey literature was excluded from the review. According to the definition of Schopfel et al, 2011, “Grey literature stands for manifold document types produced on all levels of government, academics, business and industry in print and electronic formats that are protected by intellectual property rights, of sufficient quality to be collected and preserved by library holdings or institutional repositories, but not controlled by commercial publishers i.e., where publishing is not the primary activity of the producing body.”

Type of participants

Young and healthy, male and female soccer players under 20 years old that play on soccer clubs of either amateur or professional level were the type of participants that participated in the eligible studies that were included in this review.

Type of interventions

Studies that investigated the effects of plyometric training in explosive actions such as sprinting, jumping, kicking speed and agility on the performance of soccer players.
were included. The period of intervention (plyometric training) had to be at least one week. The studies had to have more than one participant necessarily under the age of 20. Case studies that were excluded from this review.

**Ethical considerations**

Due to the nature of systematic reviews ethical heterogeneity among studies may exist and therefore for some studies included in systematic reviews, ethical considerations could be of insufficient quality (Vergnes et al, 2010). Following the recommendation by Weingarten et al (2004) only studies with a clearly stated ethical approval were included in the present review. Therefore, all the studies were additionally screened on the criterion of the ethical approval.

**Type of outcome measures**

**Primary outcomes**

Sprinting, jumping, agility and kicking speed as measured by validate specific tests on its aspect of performance.

**Search methods for identification of studies**

**Search Strategy**

To identify articles for the review, the PubMed, Web of Science and the SPORTDiscus databases were searched. A time frame from January 2000 to August 2017 was applied for the search to focus on state-of-the-art research. Relevant controlled vocabulary terms and key terms related to the topic of the dissertation were used for the search. More specifically the following words were used as key-terms to conduct the literature search: *plyometric training, plyometrics, soccer, soccer players*.

To conduct the keyword search the following Boolean search string was compiled and applied: (“plyometric training” OR “plyometrics”) AND (“soccer” OR “soccer players”) for studies published from 01/01/2000 to 6/08/2017. The search was performed on 6 August 2017 by the author.
Data collection and analysis

Search results
The search yielded several relevant studies. Precise number for each database are presented in Table 1.

Table 1. Quantification of search results according to each database.

<table>
<thead>
<tr>
<th>Database</th>
<th>Retrieved</th>
<th>Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPORTDiscus</td>
<td>165</td>
<td>10</td>
</tr>
<tr>
<td>PubMed</td>
<td>97</td>
<td>11</td>
</tr>
<tr>
<td>Web of Science</td>
<td>172</td>
<td>3</td>
</tr>
</tbody>
</table>

Study Selection
Specific inclusion and exclusion criteria were used to better match the review with our research questions to be answered. Inclusion and exclusion criteria is presented in detail in Table 2.

Table 2. Inclusion and exclusion criteria of the review

Inclusion criteria

- **Topic**: The efficacy of plyometric training on explosive actions on the performance of young soccer players
- **Types of intervention**: Research comparing the effects of plyometric training on explosive actions, i.e. sprinting, jumping, kicking speed and agility
- **Population**: Soccer players, male and female, under 20 years old, amateurs and professionals, healthy athletes.
- **Language**: English
- **Study types**: Randomized control trials, Experimental studies with control group, Experimental studies with one group only
- **Publication type**: Peer reviewed academic journal articles
- **Ethical approval**: Studies with a clearly declared ethics approval
**Time frame**  
2000-2017

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**Exclusion criteria**

*Types of intervention*  
Studies examining the efficacy of plyometric training on other soccer actions (e.g. strength)

*Population*  
Athletes over 20 years old, injured athletes, athletes with mental health issues

*Study types*  
Grey literature

*Publication type*  
Edited books, editorials, dissertations, commentaries, narrative reviews, newspaper/nonacademic sources, bulletins, conference abstracts/papers, popular culture

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**Assessment of risk of bias in included studies**

The recommendations and guidelines of the Cochrane handbook for systematic reviews (Higgins and Green, 2011) were used to assess the quality of the methodological approach that was followed in each of the included studies. The risk of bias was assessed after the consideration of the design and conduction of the studies of each study separately. The approach provided in the Cochrane guidelines (Higgins et al, 2011) was followed to define the risk of bias summary assessments (high risk, unclear risk and low risk of bias) for each one of the included studies. The sources of risk of bias that were assessed in each study are the following:

- **Selection bias**  
  (Random sequence generation and Allocation concealment)

- **Performance bias**  
  (Blinding of participants and personnel)

- **Detection bias**  
  (Blinding of outcome assessment)

- **Attrition bias**  
  (Incomplete outcome data)

- **Reporting bias**  
  (Selective reporting)
Other bias

Grading of Evidence
The GRADE (Grading of Recommendations Assessment, Development, and Evaluation) system which is adopted by the Cochrane Collaboration in order to rate the quality of the body of scientific evidence in the systematic review (Schünemann et al, 2008). The GRADE approach specifies four levels of quality. The four levels of quality consist of high, moderate, low and very low. Randomised trials have the highest quality ratings and observational studies are considered to have low ratings. For the purpose of this systematic review, the randomised studies were allocated the high rating and the experimental studies the low. After the upgrading and degrading the randomised trials can be degraded to maximum 3 levels and the experimental studies can be upgraded to high and moderate levels.

Results
Description of studies
Result of the search
The total number of articles that were found initially through electronic searches was 434. After the removal of 15 duplicates, 419 studies remained. At this point, abstracts were read for 419 studies that had a potential to be deemed as relevant and 364 articles were excluded due to their title. 55 articles were read in full and assessed for eligibility by the inclusion and exclusion criteria of the review (population, language, study types, publication type, ethical approval, and time frame) and 31 articles were excluded. 24 was the final number of articles that selected and considered eligible for the review. The flow chart of the selection of articles is shown in Figure 1.
Concerning the efficacy of plyometric training on each explosive action of young soccer players separately, it was found that out of the total 24 studies the 22 of them were dealing with jumping, 23 sprinting, 9 ball kicking and 19 with agility. The total
number of subjects that took part in the studies that were included in the review was 877.
<table>
<thead>
<tr>
<th>Author &amp; Year</th>
<th>Methods</th>
<th>Participants</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Main results</th>
<th>Risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meylan and Malatesta (2009)</td>
<td>Experimental with one intervention group and one control group. Length: 8 weeks</td>
<td>Soccer players. Total: 25 TG: n= 14 CG: n=11 Age: 13.2 ± 0.6 years.</td>
<td>TG performed various plyometric drills for 20 to 25 minutes as a substitute for some soccer drills within the usual 90-minute practice twice per week. Plyometric drills included multiple jumps (ankle hop, vertical and lateral hurdle jump), horizontal and lateral bounding, skipping, and footwork (speed ladder). CG: Regular soccer training only</td>
<td>Tests: - linear sprint test, - agility test - countermovement jump</td>
<td>TG: Beneficial impact on linear sprint training (-2.1%, p = 0.004), agility (-9.6%, p&lt;0.001) and countermovement jump (7.9%, p&lt;0.004). CG: No significant changes.</td>
<td>High</td>
</tr>
<tr>
<td>Rubley et al, (2011)</td>
<td>Group-assigned, mixed-model experimental design with one intervention group and one control group. Length: 14 weeks.</td>
<td>Soccer players. Total: n=16 PTG: n=10 CG: n=6 Age: 13.4 ± 0.5 years</td>
<td>PTG: various types of jumps, hops, skips, footwork, and sprint drills. First 6 weeks: single-leg forward hops over 6-inch cones, double-leg hops over 10-inch hurdles, lateral hops over 10-inch hurdles, and lateral shuffles over a 12-inch box. Final 6 weeks: 10-inch box jump-ups, 10-inch depth jumps, and cutting drills. CG: Regular soccer training only</td>
<td>Tests: - Vertical jump test - Kicking distance test</td>
<td>PTG: Significant increases of performance in kicking distance and vertical jump distance after 14 weeks (p&lt;0.001). Significant increase in vertical jump after 14 weeks (p&lt;0.014). CG: No significant changes.</td>
<td>High</td>
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| Michailidis et al, (2013)           | RCT     | Soccer players. Total: n=45  
PTG: n=24  
CG: n=21  
Age: 10.6 ± 0.5 years | PTG: The first PT phase or macrocycle (6 weeks) consisted of single and double-leg forward hops over hurdles, lateral hops over hurdles, and lateral shuffles over a box, skipping, and footwork. The second PT macrocycle (6 weeks) consisted of footwork, skipping, single- and double-leg box jumps and relatively low-intensity depth jumps.  
CG: Regular soccer training only | Tests:  
- linear sprint test  
- leg muscle power test  
- standing long jump test  
- leg strength test  
- anaerobic power test  
- agility test  
- kicking distance test | PTG: Significant (p<0.05) beneficial changes in sprinting (3 -5%), jumping performance (16-23%) leg strength (28%), agility (23%) and kicking distance (22.5%). Anaerobic power remained unaffected in both groups.  
CG: No significant changes. | Unclear |
| Ramirez-Campillo et al, (2014)      | RCT     | Soccer players. Total: n=76  
TG: n=38  
CG: n=38  
Age: 13.2 ± 1.8 years | TG: Plyometric drills including 2 sets of 10 repetitions of drop jumps from 20, 40, and 60 cm (i.e., 60 contacts) performed on a grass soccer field.  
CG: Regular soccer training only | Tests:  
- linear sprint test  
- agility test  
- countermovement jump test  
- drop jump  
- maximal kicking test for distance  
- 2.4-km time trial test | TG: Plyometric training induced significant (p<0.05) improvements in countermovement jump (4.3%), drop jump (16%) and agility (~3.5%) maximal kicking distance (14%) and had nonsignificant effect on sprinting.  
CG: No significant changes. | Low |
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<tr>
<td>Cavaco et al, (2014)</td>
<td>RCT</td>
<td>Soccer players. Total: n=16 GCT1: n=5 GCT2: n=5 CG: n=6 Age: 13.80±0.84</td>
<td>The subjects of the GCT1 and GCT2 performed their normal soccer training along with the CTX program (1 session per week for the GTC1 and 2 sessions per week for the GCT2). The CG group performed only regular soccer training. All groups performed similar soccer training. CG: Regular soccer training only.</td>
<td>Tests:</td>
<td>GCT1, GCT2: No significant differences with control group except for shooting effectiveness, p=0.02. CG: No significant changes.</td>
<td>Unclear</td>
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<tr>
<td>Söhnlein et al, (2014)</td>
<td>Experimental study design with one intervention and one control group.</td>
<td>Soccer players. Total: n=22 PTG: n=12 Age: 12.3 0.8 years CG: n=10 Age: 13.0 ± 0.9</td>
<td>PTG: During every vertical horizontal PT session, the following jumps were performed: 2-footed ankle hop forward, hurdle jumps (with height increasing during the 16 weeks), single leg hop forward, and squat jump. During every lateral PT session, the following jumps were performed: lateral bound stabilization, lateral hurdle jumps, double leg zigzag, and single leg hop lateral. CG: Regular soccer training only.</td>
<td>Tests:</td>
<td>PTG: Significant improvements (p&lt;0.05) in sprinting (-3.2%), agility (-6.1%) and long jump performance (+7.3%). CG: No significant changes.</td>
<td>High</td>
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<tr>
<td>Ramirez-Campillo et al. (2015)</td>
<td>RCT</td>
<td>Soccer players. Total: n=24 Age: 13.0 ±2.3</td>
<td>PPT: Plyometric training with progressive increase in volume across time. (horizontal, vertical and bilateral and unilateral) NPPT: no progressive increase in volume CG: Regular soccer training only.</td>
<td>Tests:  - countermovement jump tests  - drop jump tests  - maximal kicking velocity  - linear sprint test  - agility test  - endurance test</td>
<td>PPT and NPPT: Significant (p&lt;0.001) changes in sprinting (-1.1%), drop jumping (21.2%) and agility (-9.0%). CG: No significant changes.</td>
<td>Low</td>
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<td></td>
<td>RCT</td>
<td>Soccer players. Total: n=54 Age: 11.4 ± 2.2 years</td>
<td>BG: Bilateral horizontal and vertical jumping exercises UG: Vertical and horizontal jumping exercises on both right and left leg B + UG: Bilateral and unilateral vertical and horizontal jumping exercises on both legs. CG: Regular soccer training only.</td>
<td>Tests:  - countermovement jump test  - drop jump test  - maximal kicking velocity, linear sprint test  - agility test, endurance test  - balance performance test</td>
<td>BG, UG, B+UG: significant changes, in maximal kicking velocity (p &lt;0.05), sprinting (p&lt;0.01) and agility (p&lt;0.001) in all groups  CG: No significant changes.</td>
<td>Unclear</td>
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<tr>
<td>Ramirez-Campillo et al, (2015)</td>
<td>RCT</td>
<td>Soccer players. Total: n=40</td>
<td>VG: vertical unilateral and bilateral plyometric exercises</td>
<td>Tests:</td>
<td>VHG: Significant changes (p≤0.05) in jumping (5%), sprinting (6%), agility (-5.1%) and maximal kicking velocity (15.5%). VG, HG: No significant changes. CG: No significant changes.</td>
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<td>VG: n=10</td>
<td>HG: horizontal unilateral and bilateral plyometric exercises</td>
<td>- countermovement jump tests</td>
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<td>HG: n=10</td>
<td>VHG: vertical and horizontal unilateral and bilateral plyometric exercises</td>
<td>- drop jump test</td>
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<td>VHG: n=10</td>
<td>CG: Regular soccer training only.</td>
<td>- reactive strength index</td>
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<td>CG: n=10</td>
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<td>- maximal kicking velocity</td>
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<td>- linear sprint test</td>
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<td>- agility test</td>
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<td>- endurance test</td>
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<td>- balance test</td>
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<td>Length: 6 weeks</td>
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<tr>
<td>Michailidis (2015)</td>
<td>RCT</td>
<td>Soccer players. Total: n=21</td>
<td>JG: Jumping (one and two leg) and running (skipping) exercises.</td>
<td>Tests:</td>
<td>JG: Significant (p &lt; 0.05) changes in jumping (p&lt;0.03) and sprinting 7.2%, p&lt;0.001</td>
<td>Unclear</td>
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<td></td>
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<td>JG: n= 11</td>
<td>CG: Regular soccer training only.</td>
<td>- linear sprint test</td>
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<td>CG: n=10</td>
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<td>- standing long jump.</td>
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<tr>
<td></td>
<td>Length: 10 weeks</td>
<td>Age: 11.4± 0.6</td>
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<tr>
<td>Blanco et al, (2015)</td>
<td>Quasi-experimental design Lenth: 6 weeks</td>
<td>Soccer players. Total: n=38 STG: n=20 CG: n=18 Age: 14.7 ± 0.5</td>
<td>STG: Resistance training program combined with plyometrics plus a soccer training program. Strength training consisted of full squats with low load (45–60 % 1RM) and low volume (2–3 sets and 4–8 repetitions per set) combined with jumps and sprints twice a week CG: Regular soccer training only.</td>
<td>Tests: - linear sprint test - countermovement jump - one-repetition maximum test</td>
<td>STG: Significant (p&lt;0.05) improvement in countermovement jump, vertical jump and sprinting. CG: No significant changes.</td>
<td>High</td>
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<tr>
<td>Author &amp; Year</td>
<td>Methods</td>
<td>Participants</td>
<td>Interventions</td>
<td>Outcome measures</td>
<td>Main results</td>
<td>Risk of bias</td>
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<tr>
<td>Ramirez-Campillo et al, (2015)</td>
<td>RCT</td>
<td>Soccer players. Total: n=166</td>
<td>The PT groups performed plyometric drills as a substitute for some soccer drills within the usual 120-minute practice twice per week for 6 weeks. PT24 and PT48 completed the same number of total jumps during intervention. Half of the plyometric volume corresponds to cyclic and the other half to acyclic jumps.</td>
<td>Tests: - squat jump test - countermovement jump test - drop jump test - long jump test - linear sprint test - agility test - shuttle run test, - sit-and-reach test</td>
<td>PT24, PT48: Significant improvements (p&lt;0.001, p&lt;0.05) in jumping (12.2%), sprinting (-5.6%) and agility (-2.7%). CG: No significant changes.</td>
<td>Low</td>
</tr>
<tr>
<td>Loturco et al, (2015)</td>
<td>RCT</td>
<td>Soccer players. Total: n=24</td>
<td>Total of 11 jump training (VJ or HJ) sessions were performed by each group, lasting between 18 and 27 min each. The shape of the overloading was pyramidal in the first 10 training sessions, divided in blocks of 2 training sessions. The VJ consisted of countermovement jumps (CMJ) with the hands on the hips, while the HJ were performed with arms swinging.</td>
<td>Tests: - Countermovement jumps (CMJ) - Horizontal jumps (HJ) - Sprinting speed 5-10-20 m</td>
<td>VJG, HJG: Significant improvements (p&lt;0.05) in jumping and sprinting. CG: No significant changes.</td>
<td>Low</td>
</tr>
<tr>
<td>Author &amp; Year</td>
<td>Methods</td>
<td>Participants</td>
<td>Interventions</td>
<td>Outcome measures</td>
<td>Main results</td>
<td>Risk of bias</td>
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<tr>
<td>Kobal et al, (2016)</td>
<td>RCT</td>
<td>Soccer players. Total: n=27 CP: n=9 TD: n=9 CT: n=9 Age: 18.9 ± 0.6 years</td>
<td>CP: Strength training (ST) before plyometric training (PT). TD: PT before ST. CT: ST and PT performed alternately, set by set. The ST composed of half-squat exercises performed at 60–80% of 1 repetition maximum (1RM); the PT composed of drop jump exercises executed in a range from 30 to 45 cm.</td>
<td>Tests: - countermovement jumps - agility test - linear sprint test - Half-Squat Maximum - Dynamic Strength</td>
<td>CP, TD, CT: No significant increases in jumping, sprinting and agility (p&gt;0.05)</td>
<td>High</td>
</tr>
<tr>
<td>Granacher et al, (2016)</td>
<td>Experimental study with two intervention groups. Length: 30–35-min plyometric training regime incorporating multiple sets of CMJs, DJs and hurdle CMJs. Participants of the SPT group performed all jump exercises on stable surfaces and subjects in the IPT group executed the same exercises on highly unstable surfaces that are frequently used during athletic training and rehabilitation.</td>
<td>Soccer players. Total: n=24 SPT: n=12 IPT: n=12 Age: 15 ±1 years</td>
<td>Tests: - jump performance test - countermovement jump test - drop jump test - linear sprint test - agility test - balance test</td>
<td>SPT, ITP: Significant differences in jumping (p&lt;0.001), sprinting (p&lt;0.05) and agility (p&lt;0.001) between groups</td>
<td>Unclear</td>
<td></td>
</tr>
<tr>
<td>Author &amp; Year</td>
<td>Methods</td>
<td>Participants</td>
<td>Interventions</td>
<td>Outcome measures</td>
<td>Main results</td>
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<tr>
<td>Negra et al, (2016)</td>
<td>RCT</td>
<td>Soccer players. Total: n=28 E: n=15 CG: n=13 Age: 15.7 ± 0.2 years.</td>
<td>E: Plyometric training program consisting of hurdle and drop jumps. CG: Regular soccer training only.</td>
<td>Tests: - agility tests - linear sprint tests</td>
<td>E: Significant (p&lt;0.05) gains in jumping, sprinting and agility tests. CG: No significant changes.</td>
<td>Unclear</td>
</tr>
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<tr>
<td>Negra et al, (2016)</td>
<td>RCT</td>
<td>Soccer players. Total: n=34 RTG: n=12 PTG: n=11 CG: n=11 Age = 12.8 ± 0.2</td>
<td>RTG: low-to-moderate training load (40%-60% of 1RM) was adjusted and increased over the course of the training. PT: vertical-horizontal leap sessions (2-footed ankle hop forward, hurdle jumps, and squat jump) and lateral jumping sessions (lateral bound stabilization, lateral hurdle jumps, and double-leg zigzag). CG: Regular soccer training only.</td>
<td>Tests: - muscle strength test - jump ability test - linear sprint test - agility test</td>
<td>RTP, PTG: Significant improvements (p&lt;0.005) in both groups in sprinting (4.3%), jumping (7%) and agility (3.8%). CG: No significant changes.</td>
<td>Unclear</td>
</tr>
<tr>
<td>Author &amp; Year</td>
<td>Methods</td>
<td>Participants</td>
<td>Interventions</td>
<td>Outcome measures</td>
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<tr>
<td>Negra et al, (2017)</td>
<td>RCT</td>
<td>Soccer players. Total: n=34 SPT= 18 UPT= 16 Age = 12.7 ± 0.2 years</td>
<td>The first plyometric training session of each training week focused on improving the vertical leap, whereas the second plyometric training session focused on improving the horizontal jumping ability. Participants of the SPT group performed all jump exercises on stable surfaces and subjects in the UPT group executed the same exercises on highly unstable surfaces.</td>
<td>Tests: - jumping ability test - standing long jump test - linear sprint test - agility - balance test</td>
<td>SPT, UPT: No Significant differences (p&gt;0.05) in both groups.</td>
<td>Unclear</td>
</tr>
<tr>
<td>Author &amp; Year</td>
<td>Methods</td>
<td>Participants</td>
<td>Interventions</td>
<td>Outcome measures</td>
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<td>Risk of bias</td>
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<tr>
<td>Chaabène and Negra (2017)</td>
<td>Quasi experimental study with two intervention groups. Length: 8 weeks</td>
<td>Soccer players. Total: n=25 LPT: n=13 years HPT: n=12 years Age = 12.70±0.25 years</td>
<td>The two experimental groups participated in an 8-weeks in-season PT program with 2 training sessions per-week. Both groups conducted five soccer training sessions per-week and two plyometric training sessions were integrated into the regular soccer training routine every first PT session in each week was focused on improving the vertical leap (i.e., CMJs), whereas every second PT session was focused on improving the horizontal jumping ability (i.e., two-footed ankle hop forward). Players were instructed to perform at maximal intensity.</td>
<td>Tests: - Linear sprint test - agility - vertical jump test - counter-movement jump test - horizontal standing-long-jump test</td>
<td>LPT, HPT: significant effects on sprinting (p=0.05), agility (p=0.02), horizontal (p=0.07) and vertical jump ability (p=0.08) on both groups.</td>
<td>High</td>
</tr>
<tr>
<td>Thomas et al, (2017)</td>
<td>Randomized, between-group design experimental study with two intervention groups. Length: 6 weeks</td>
<td>Soccer players. Total: n=12 DJ: n=7 CMJ: n=5 years Age = 17.3 ± 0.4 years</td>
<td>CMJ group performed exercises that always began with a countermovement, defined as a flexion of the knees. During rebound exercises, participants in this group were told to “damp” their landings each time and to gain maximum height through knee flexion. Participants in the DJ group performed exercises that always began with a drop from a height (40 cm). Participants in the DJ group were instructed to minimize ground-contact time while maximizing height.</td>
<td>Tests: - countermovement vertical jump test - linear sprint speed - agility test</td>
<td>DJ, CMJ: Improvements in vertical jump height (p &lt; 0.05) and agility time (p &lt; 0.05) and no change in sprint performance (p &gt;0.05). No difference (0&gt;0.05) between groups.</td>
<td>Unclear</td>
</tr>
<tr>
<td>Author &amp; Year</td>
<td>Methods</td>
<td>Participants</td>
<td>Interventions</td>
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</table>
| Chaouachi et al, (2017) | RCT     | Soccer players. Total: n=26 ABPT: n=13 BBPT: n=13 Age: 13.9 ± 0.3 years. | ABPT group: alternated balance exercises prior to plyometric exercises in pairs. BBPT group: blocks of balance exercises prior to plyometric exercises. | Tests:  
- strength test  
- power test  
- agility test  
- linear sprint,  
- balance test  
- isometric back and knee extension strength,  
- standing long jump test  
- Y-balance test | ABPT, BBPT: Significant (p<0.001) improvements in jumping (20%), sprinting (-4%) and agility (-8%) on both groups. | Unclear |
| Chtara et al, (2017)   | RCT     | Soccer players. Total: n=42 PLYO: n=10 AG: n=10 RS: =10 CG: n=12 Age: 13.6±0.3-years. | PLYO training = 9 lower limb exercises (2-3 sets of 8-12 repetitions). The AG group performed planned AG drills and direction changes. RS training consisted of 2-4 sets of 5-6x 20 to 30 m shuttle sprints (20 seconds recovery in between). CG: regular soccer training. | Tests:  
- horizontal jump tests  
- linear sprint test  
- agility test  
- repeated sprint ability test | PLYO, AG, RS: Significant pre to post trainings effects (p<0.05 and p<0.01) on all groups in sprinting (4%), jumping (7.9%) and agility(4.02%). CG: No significant changes. | Unclear |
TG= training group, PTG=plyometric training group, RCT= randomized controlled trial, SQ = back squat group, RS = resisted sprint group;
PLYO = plyometric and speed/agility group, BM=Body Mass, COD=change of direction, JG= Jumping Group, CG= Control Group,
PPT=progressive plyometric training, NPPT=non progressive plyometric training, BG = Bilateral plyometric training group, UG = unilateral plyometric training group; B + UG = combined bilateral + unilateral plyometric training group, CombG= combined group, PT24= plyometric training groups with 24 hours of rest, PT48= Plyometric training groups with 48 hours of rest, VG=vertical plyometric group, HG=horizontal plyometric group, VHG=vertical and horizontal group, RTG= resistance training group RT=resistance training, PT=plyometric training, RCOD=repeated change-of-direction test, STG=strength training group CP=complex training, TD=traditional training, CT=contrast training, SPT= stability plyometric training surfaces, IPT= instability plyometric training, PTG=plyometric training group, GCT1= a group that performed one weekly CXT, GCT2= session group that performed two weekly CXT sessions, CONT=a control group that did not perform CTX, PLYO=plyometrics, AG=agility, RS=repeated sprint, LPT=low-volume plyometric training group, HPT=High-volume plyometric training group, IPT=plyometrics on unstable surfaces, VJG=vertical jumping group, HJG=horizontal jumping group, ABPT=individual balance and plyometric exercises, BBPT= block of balance exercises prior to a block of plyometric exercises.
Included studies

Author and year of studies

Twenty-four studies were included dated from 2009 to 2017. Eighteen studies (75%) were published after 2015.

Methods

The included studies in this review had different types of design. Sixteen studies were randomized control trials (Michailidis et al, 2013; Ramirez-Campillo et al, 2014; Cavaco et al, 2014; Ramirez-Campillo et al, 2015; Ramirez-Campillo et al, 2015; Ramirez-Campillo et al, 2015; Michailidis et al, 2015; Sáez de Villarreal et al, 2015; Ramirez-Campillo et al, 2015; Loturco et al, 2015; Kobal et al, 2016; Negra et al, 2016; Negra et al, 2016; Negra et al, 2016; Chaouachi et al, 2017; Chtara et al, 2017) all of which had a control group except for the studies of Loturco et al, 2015 and Kobal et al, 2016 which had two and three intervention groups only respectively.

Four studies (Meylan & Malatesta, 2009; Rubley et al 2011; Söhnlein et al, 2014 and Blanco et al, 2015) were of experimental design with both intervention and control groups while the other four studies (Granacher et al, 2016; De Hoyo et al, 2016; Chaabene & Negra 2016 and Thomas et al, 2017) only had intervention groups. The control groups in all studies performed only their regular soccer training.

Participants

The total number of participants that took part in the studies was 877. The number of participants that participated on each study ranged from 12 to 166 with a range of mean age from 10 to 19 years. Between one and four groups were used in the studies and the number of participants ranged in each group from 6 to 57.

Interventions

Studies with control group

variety of plyometric drills as intervention on the intervention groups while the control groups performed only their regular soccer training. The variety of plyometrics included the following exercises: multiple jumps (ankle hop, vertical and lateral hurdle jump), horizontal and lateral bounding, skipping, and footwork (speed ladder), single-leg forward hops over 6-inch cones, double-leg hops over 10-inch hurdles, lateral hops over 10-inch hurdles, and lateral shuffles over a 12-inch box, 10-inch box jump-ups, 10-inch depth jumps, and cutting drills.

Studies with no control groups

Eight studies (Cavaco et al, 2014; Loturco et al, 2015; De Hoyo et al, 2016; Chaabene & Negra, 2016; Granacher et al, 2016; Negra et al, 2017; Negra et al, 2017; Thomas et al, 2017; Chaouachi et al, 2017) used only intervention groups, which had different plyometric drills as interventions or combination of plyometrics with strength training.

Outcomes

The participants in all studies were trained in plyometric training and used valid and reliable tests for running, jumping ability, kicking speed and agility.

Main results – significant findings

Out of the total number of 24 studies of the review, 18 studies (Meylan & Malatesta 2009; Michailidis et al 2013; Söhnlein et al 2014; Ramirez-Campillo 2015; Ramirez-Campillo 2015; Ramirez-Campillo 2015; Michailidis et al 2015; Saez de Villareal et al 2015; Blanco et al 2015; Ramirez-Campillo et al 2015; Loturco et al 2015; Granacher et al 2016; Negra et al 2016; Negra et al 2016; Hoyo et al 2016; Chaabene & Negra 2017; Chaouachi et al 2017; Chtara et al 2017) showed significant (p<0.05) improvement that plyometric training had on sprinting ability of young soccer players. 20 studies (Meylan & Malatesta 2009; Rubley et al 2011; Ramirez-Campillo et al 2014; Söhnlein et al 2014; Ramirez-Campillo 2015; Ramirez-Campillo 2015; Ramirez-Campillo 2015; Michailidis et al 2015; Saez de Villareal et al 2015; Blanco et al 2015; Ramirez-Campillo et al 2015; Loturco et al 2015; Granacher et al 2016; Negra et al 2016; Negra et al 2016; Hoyo et al 2016; Negra et al 2017; Chaabene & Negra 2017; Chaouachi et al 2017; Thomas et al 2017; Chtara et al 2017) showed significant (p<0.05) improvement that plyometric training had on jumping ability of
young soccer players, 14 studies (Meylan & Malatesta 2009; Ramirez-Campillo et al 2014; Ramirez-Campillo 2015; Ramirez-Campillo 2015; Ramirez-Campillo 2015; Saez de Villareal et al 2015; Ramirez-Campillo et al 2015; Granacher et al 2016; Negra et al 2016; Negra et al 2017; Chaouachi et al 2017; Thomas et al 2017; Chtara et al 2017; Ramirez-Campillo et al 2014; Ramirez-Campillo 2015; Ramirez-Campillo 2015; Saez de Villareal et al 2016) showed significant (p<0.05) improvement that plyometric training had on agility and 5 studies (Rubley et al 2011; ; Ramirez-Campillo et al 2014; Ramirez-Campillo 2015; Ramirez-Campillo 2015; Saez de Villareal et al 2016) showed improvement on ball kicking ability. However, the studies of Cavaco et al (2014), Kobal et al (2016), Negra et al (2017) and Thomas et al (2017) did not show any significant positive (p>0.05) in sprinting ability. On the study of Kobal et al (2016) there was no significant positive effect (p>0.05) on jumping ability and on 4 studies (Cavaco et al, 2014, Kobal et al 2016, De Hoyo et al 2016 and Negra et al, 2017) there was no significant positive effect on agility.

**Assessment of risk of bias within each study**

Out of 24 studies, 7 studies (Meylan and Malatesta, 2009; Rubley et al, 2011; Söhnlein et al, 2014; Blanco et al, 2015; Kobal et al, 2016; Hoyo et al 2016; Chaabène and Negra 2017) were judged as of high risk of bias studies. 4 studies (Ramirez and Campillo et al, 2014; Ramirez and Campillo et al, 2015; Ramirez and Campillo et al, 2015; Loturco et al, 2015) were judged as low risk of bias studies and the rest 13 studies (Michailidis et al, 2013; Cavaco et al, 2014; Ramirez-Campillo et al, 2015; Ramirez-Campillo et al, 2015; Michailidis 2015; Sáez de Villarreal et al, 2015; Granacher et al, 2016; Negra et al 2016; Negra et al 2017; Negra et al, 2017; Thomas et al, 2017; Chaouachi et al, 2017; Chtara et al, 2017) were judges as unclear risk of bias studies.
<table>
<thead>
<tr>
<th>Study</th>
<th>Random sequence generation</th>
<th>Allocation concealment (Selection bias)</th>
<th>Blinding of participants and personnel (performance bias)</th>
<th>Blinding of outcome assessment (detection bias)</th>
<th>Incomplete outcome data (attrition bias)</th>
<th>Selective reporting (reporting bias)</th>
<th>Other bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meylan and Malatesta (2009)</td>
<td>-</td>
<td>-</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Rubley et al (2011)</td>
<td>-</td>
<td>-</td>
<td>?</td>
<td>?</td>
<td>-</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Söhnlein et al, (2014)</td>
<td>-</td>
<td>-</td>
<td>?</td>
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<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Chaabène and Negra (2017)</td>
<td>-</td>
<td>-</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**Figure 2.** Risk of bias on all studies.
Quality assessment – GRADE

Level of evidence

Among the total number of studies there were 16 RCT (Michailidis 2013; Ramirez-Campillo et al, 2014; Cavaco et al, 2014; Ramirez-Campillo et al, 2015; Ramirez-Campillo et al, 2015; Ramirez-Campillo et al, 2015; Ramirez-Campillo et al, 2015; Michailidis 2015; Saez de Villareal et al, 2015; Ramirez-Campillo et al, 2015; Loturco et al, 2015; Kobal et al, 2015; Negra et al, 2016; Negra et al, 2016; Negra et al, 2017; Chaouachi et al, 2017; Chtara et al, 2017) one RT (Thomas et al, 2017) and 5 EC (Meylan and Malatesta, 2009; Rubley et al, 2011; Sohnlein et al, 2015; Blanco et al, 2015; Chaabene and Negra, 2017) and 2 E (Granacher et al, 2016; Hoyo et al, 2016).

4 RCT started at the high level and were downgraded one level for imprecision of results and were upgraded one level for large effect, so they remained at high level. 13 RCT/RT studies started at the high level and were downgraded to low level because of limitations in design and imprecision of results and EC/E studies started at low level and downgraded to very low level because of limitations in design (Table 4 and 5).
### Table 4. Level of evidence

<table>
<thead>
<tr>
<th>No. of studies (subjects)</th>
<th>Design (strength of evidence)</th>
<th>Limitations in design</th>
<th>Indirectness of evidence</th>
<th>Unexplained heterogeneity or inconsistency of results</th>
<th>Imprecision of results</th>
<th>Publication bias</th>
<th>Large effect</th>
<th>Confounders</th>
<th>Dose-response</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 RCT (289) “moderate level”</td>
<td>RCT (4)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13 RCT/RT “Low level”</td>
<td>RCT/RT (4)</td>
<td>-12</td>
<td>0</td>
<td>0</td>
<td>-11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7 EC/E “very low level”</td>
<td>EC/ E (2)</td>
<td>-13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

RCT=Randomized control trials, RT= Randomized trials, EC= Experimental and control group, E=Experimental group only

1. Low number of included subjects
2. Large p-value <0.5
3. Lack of allocation concealment, blinding and other bias
### Table 5. Summary of findings

<table>
<thead>
<tr>
<th>Design no. of subjects (no. of students)</th>
<th>Strength min - max change when compared to baseline or control</th>
<th>p-value&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Evidence according to GRADE</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4 RCT</strong></td>
<td>RCT (289)</td>
<td>+13 to +42%</td>
<td>p&lt;0.001</td>
<td>Moderate level</td>
</tr>
<tr>
<td></td>
<td>(4 studies included for calculation)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>13 RCT/RT</strong></td>
<td>RCT/RT (460)</td>
<td>-7 to +28%</td>
<td>p&lt;0.01</td>
<td>Low level</td>
</tr>
<tr>
<td></td>
<td>(13 studies for calculation)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>7 EC/E</strong></td>
<td>EC/E (128)</td>
<td>+3 to 27%</td>
<td>P&lt;0.05</td>
<td>Very low level</td>
</tr>
</tbody>
</table>

**RCT**=Randomized control trials **RT**= Randomized trials **EC**= Experimental and control group **E**=Experimental group only

<sup>1</sup> Highest p-value for included studies
Discussion

Summary of main results

The main results of the current systematic review which included 24 studies provides evidence that plyometric training has a beneficial effect on the performance of young soccer players on explosive actions such as sprinting, jumping, agility and ball kicking. The “Summary of findings” table shows that the studies were of moderate, low and very low level and the “Description of all included studies table shows the specific results of each study and the risk of bias in each study which was varying from high and unclear to low risk of bias.

Overall completeness and applicability of evidence

The databases that were selected for this review were the most appropriate due to the time frame of the thesis and the nature of the study. If the study was to be repeated the Medline database could be added. The findings of this review are applicable to physical education teachers, soccer trainers, soccer players and generally athletes. This review showed that young (under 20 years old) soccer players can be benefited from the use of plyometric training along with their regular soccer training in crucial factors of soccer performance such as sprinting, jumping, agility and kicking ability. The researchers in most of the studies observed significant improvements in these aspects of performance that they study. These aspects can help young soccer players improve their sport performance a fact that can enhance their overall soccer performance in a game. More specifically, in the studies of this review took part young soccer players between 10 and 19 years old, all of them male except for one study (Rubley et al, 2011) which subjects were female. All the studies were recent as they were published after 2000. On all studies there were subjects that participated in control groups of regular soccer training and in intervention groups of several week period that included plyometric training programs that consisted of bilateral and horizontal vertical and horizontal jumps, drop jumps squat jumps and hurdle jumps. Then they were tested in corresponding performance tests in sprinting, jumping, agility (change of direction) and kicking distance. On the majority of studies, it was shown that the intervention groups who followed plyometric training for a specific period of time as supplementary training along with their regular soccer training, had significant improvements in the performance test that they executed.
Quality of the evidence

The assessment of the quality of evidence was one of the most important factors of the review. The total 24 studies included an adequate number of subjects (877) and 17 of them were randomized trials and started at the “high level” according to GRADE and 7 were of experimental design and started at the “low level”. Four of the randomized studies downgraded to “moderate level” because of imprecision of results due to the small number of subjects included, 13 were downgraded to “low level” because of limitation in design and imprecision of results due to the small number of subjects included and the 7 experimental studies were downgraded to the “very low level” due to limitations in design. Therefore, these assessments influence the confidence of the review which generally is limited, and the true effect may be substantially different from the estimate of the effect.

Potential biases of the review process

To avoid biases during the review the author followed some steps. The first was to do a systematic electronic search process (Higgins and Green 2011) and the second was a thorough search of the reference lists. The third step was the use of the GRADE method to assess the quality of evidence in the review, which is a standardized method for this purpose, although it can lead to different judgements among researchers. Therefore, the potential risk of biases of the review can be the electronic search for relevant studies on the possible resources, the differences in the GRADE judgement of the studies and the low quality level of a large number of the studies included.

Agreements and disagreements with other studies or reviews

The literature review studies of Michailidis (2014) and Bedoya et al, (2015) support the idea that soccer training when is supplemented with plyometric training have beneficial effects on explosive actions of football players such as sprinting, jumping, agility and ball kicking. More specifically, the study of Bedoya et al, (2015) consisted of 7 articles while the article of Michailidis (2014) consisted of 9 articles. Concerning the methodology, the authors used in their studies, Bedoya et al (2015) selected as inclusion criteria studies that used plyometric training programs to assess athletic performance, studies with soccer athletes as subjects, aged 10 up to 17 years old, and studies that were published from 2000 to January 2014. The articles were
searched in the following databases: MEDLINE/PubMed, Academic Search Premier, SPORTDiscus, and Cumulative Index to Nursing and Allied Health Literature (CINAHL). Michailidis (2014) selected the articles that he used in his study according to the following criteria: a) the inclusion of people under 18 years old, b) the inclusion of soccer players, c) the description of the outcomes of a plyometric exercise intervention, d) the inclusion of measures of strength, running speed or jumping ability e) the use of a randomized control trial or quasi experimental design and f) the publication in peer-reviewed journals. The articles that were used in his study were published until 2014 and the databases used were the MEDLINE, the Scopus and the SportDiscus. Also, both these studies used the PEDro (Physiotherapy Evidence Database) scale (PEDro scale) to determine the quality of the evidence for each article of their studies, in opposition to the current review that used the GRADE system for the quality of the evidence of the studies that were included. Concerning the results on these studies all of them used similar valid and reliable performance tests and in the most of them there were shown significant improvements in the aspects that were tested such as sprinting, jumping, agility and ball kicking like in the current study. Both studies suggest twice to three times a week program for 8-10 weeks beginning at 50-60 jumps the first week and progress to 100-120 by the end in agreement with this study.

Author’s conclusions

Implications for practice

The level of evidence of the review is moderate which means that further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate. The author recommends that young soccer players could enhance their motor performance including explosive actions such as sprinting, jumping, agility and ball kicking with the use of plyometric training along with their regular soccer training. It is of great importance though that the soccer coaches and the players should initially take into serious consideration the safety guidelines and get familiarized with the techniques of the plyometric training exercises. It is suggested that plyometric training can be used twice a week with graduate progress in each session, preferably on stable surfaces and in combination with strength and soccer training on age groups between 11 and 19 years old. The study suggests the use of
plyometric training twice to three times a week program for 8-10 weeks beginning at 50-60 jumps the first week and progress to 100-120 by the end to avoid injuries because of overuse. The level of evidence of the review is moderate which means that further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

**Implications for research**

The future research in this field should include more articles of randomized control type with increased quality of evidence and lower risk of bias. Moreover, more interventions about ball kicking ability should be done as there are not a lot so far. Lastly, it is of great importance for the authors in the future to assess the physiological mechanisms that contribute to the increase of these aspects of performance that comes with plyometric training.

**Declaration of interest**

The author has no conflict of interest relating to this study. There were no sources of funding to assist this review.
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players. *Experimental and Therapeutic Medicine, 12*(2), 550–554.