Plyometric training programs for young soccer players: a systematic review

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Abstract

The purpose of this systematic review was to evaluate the effectiveness of plyometric training programs on motor performance of young soccer players. Research articles were selected if met the next inclusion criteria a) included young persons under 18 years old, b) included soccer players, c) described the outcomes of a plyometric exercise intervention, d) included measures of strength, running speed or jumping ability and e) used a randomized control trial or quasi experimental design, f) published in peer-reviewed journals.

Nine studies used for the final review. The 9 studies were judged to be of low quality (values of 3-6). Most of the studies found statistically significant effects of improving motor performance (speed, jumping ability, strength, agility, kicking performance) after a plyometric training program. The current evidence suggests that a twice a week program for 8-10 weeks beginning at 50-60 jumps the first week and progress to 100-120 by the end. When soccer practice is supplemented with a plyometric training protocol it leads to greater performance gains.

Key words: plyometric training, power performance, children, soccer

Introduction

Soccer players have to master an extremely wide variety of running and jumping movements because the game tends to be dominated by dynamic and even explosive movements like sprints and sudden changes of direction (Bangsbo et al., 2006). These kinds of movements that characterized of power are very important for a successful soccer player although represent only a small percentage of a match’s total time (Reilly et al., 2000). These explosive actions are significant and for the performance of young soccer players.

The last decade’s power training is common in weekly soccer practice. One major kind of power training is the plyometric exercises. Despite its well established effectiveness in adults as a part of physical conditioning training program the trainers are confused about the use of plyometrics in young soccer players. Some years before plyometric training were deemed unsafe for youth until an update from the National Strength and Conditioning Association determined that this recommendation was not supported by current research (Faigenbaum et al., 2009).

Plyometric exercises are characterized by the use of the stretch-shortening cycle that develops during the transition from a rapid eccentric muscle contraction to a rapid concentric muscle contraction (Markovic and Mikulic, 2010; Markovic et al., 2007). These exercises can improve jumping ability (Gheri et al., 1998; King and Cipriani, 2010; Fatouros et al., 2000) speed, acceleration (Kraemer et al.,
Currently a limited number of studies have examined the influence of plyometric exercise on young soccer players. Evidence from studies with boys from other sports as basketball suggest that plyometric training may be beneficial for maintenance or enhancement of the athletic performance when they are combined with resistance training and sport specific training (Brown et al., 1986; Matavulj et al., 2001).

The purpose of this systematic review was to examine the extent and quality of the current research literature to evaluate the efficacy and safety of plyometric for improving motor performance in young soccer players. Also this review will help for a deeper understanding about the characteristics of plyometric training in young soccer players.

Materials and Methods

Computerized literature searches of articles until March 2014 were performed with the use of MEDLINE, Scopus and SportDiscus databases. The following search terms were used in different combinations to identify articles that performed plyometric exercise in young soccer players: “soccer,” “football,” “children,” “young,” “plyometric exercise,” “plyometric training,” “jumping training,” “strength,” “sport performance.”

Inclusion Criteria and quality of the articles

Research articles were selected if they a) included young persons under 18 years old, b) included soccer players, c) described the outcomes of a plyometric exercise intervention, d) included measures of strength, running speed or jumping ability and e) used a randomized control trial or quasieperimental design, f) published in peer-reviewed journals. Articles that met the 6 criteria were chosen for the final review.

Methodological quality of the included studies was evaluated by using the PEDro (Physiotherapy Evidence Database) scale (PEDro scale). Although this scale has 11 items, only ten are scored, so the score ranges from zero to ten. Each criterion except the first scored as 0 or 1. Table 1 describes the results of the quality rating.

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Data extraction

Data extraction performed by the author considering: 1) aspects of the study design and protocol; 2) aspects of the study population, such as mean age, and gender; 3) aspects of the intervention such as sample size, type of exercise, frequency and duration of the training program; 4) aspects of the variables that measured and 5) reported results.

Also effect sizes were calculated for those studies that reported means and SDs using Cohen’s d. Cohen’s description was used to classify effect sizes as small, medium or large (Cohen, 1998).

### Table 2: Characteristics and results of the studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Purpose</th>
<th>Design</th>
<th>Protocol</th>
<th>Sample</th>
<th>Indices</th>
<th>Measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sohnlein et al. 2014</td>
<td>PT for improving sprint, agility and jumping</td>
<td>non random assigned</td>
<td>16 wks; 2 × wk; 24 sessions; 112 jumps/session initial, 350 end; increase 15 jumps/wk</td>
<td>PTG n = 10 13.0 ± 0.9 yrs 12.3 ± 0.8 yrs males</td>
<td>speed, agility, shuttle run, MB5, long jump</td>
<td>baseline, every 4 wks</td>
<td>PTG: speed time ↓3.2 %, agility time ↓6.1 %, MB5 ↑11.8 %, LJ ↑7.3 %, P &lt; 0.05</td>
</tr>
<tr>
<td>Marques et al. 2013</td>
<td>Effect of jump &amp; sprint training program on strength &amp; speed abilities</td>
<td>random assigned</td>
<td>6 wks; 2 × wk; 12 sessions; 136 jumps/session initial, 185 end; increase 8 jumps/wk</td>
<td>PTG n = 26 13.4 ± 1.4 yrs males</td>
<td>Speed, CMJ, kicking velocity</td>
<td>baseline, post training</td>
<td>PTG: speed time 0-30 m ↓1.7 %, kicking velocity ↑76.6 %, CMJ ↑7.7 %, P &lt; 0.05</td>
</tr>
<tr>
<td>Michailidis et al. 2010</td>
<td>Preadolescent boys exhibit plyometric trainability or not</td>
<td>random assigned</td>
<td>12 wks; 2 × wk; 24 sessions; 60 jumps/session initial, 120 end; increase 5 jumps/wk</td>
<td>PTG n = 24 10.6 ± 0.5 yrs males</td>
<td>Speed, CMJ, SJ, DJ, MB5, LJ, leg strength, wingate test, agility, kicking distance</td>
<td>baseline, mid training, post training</td>
<td>PTG: speed ↑13-5 %, vertical jump ↑16-23 %, LJ ↑4.2 %, MB5 ↑23 %, leg strength ↑28 %, agility ↑23 %, anaerobic power ↓, kicking distance ↑22.5 %, P &lt; 0.05</td>
</tr>
<tr>
<td>Rubley et al. 2011</td>
<td>PT effects on vertical jump and kicking distance</td>
<td>quasieperimental conveniences sample</td>
<td>14 wks; 1 × wk; 14 sessions; 16 jumps/session initial, 60 end; increase 3 jumps/wk</td>
<td>PTG n = 10 13.4 ± 0.5 yrs females</td>
<td>vertical jump 5 trials, 3 best aver., kicking distance</td>
<td>baseline, post training (7 wks), post training</td>
<td>PTG: post training jump height ↑P &lt; 0.014, kicking distance ↑P &lt; 0.001</td>
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<td>Buchheit et al. 2010</td>
<td>Effects of ES vs RSS on repeated sprint ability</td>
<td>controlled study</td>
<td>10 wks; 1 × wk; 10 sessions</td>
<td>ES n = 8 RSS n = 7 14.5 ± 0.5 yrs males</td>
<td>speed, shuttle sprint test, CMJ, hopping test</td>
<td>baseline, post training</td>
<td>ES: shuttle sprint test time ↓0.08 %, CMJ ↓14.8 %, hopping test ↑27.5 %, P &lt; 0.05</td>
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<tr>
<td>Meylan &amp; Malatesta 2009</td>
<td>PT influence on explosive actions</td>
<td>quasieperimental conveniences sample</td>
<td>8 wks; 2 × wk; 16 sessions; 50 jumps/session initial, 192 end; increase 18 jumps/wk</td>
<td>PTG n = 14 13.3 ± 0.6 yrs males</td>
<td>speed, SJ, CMJ, CT, agility test, MB5</td>
<td>baseline, post training</td>
<td>PTG: speed time ↓2-1 %, agility time ↓0.6 %, CMJ ↓7.9 %, CT ↑10.9 %</td>
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<tr>
<td>Thomas et al. 2009</td>
<td>2 PT techniques on muscular power and agility</td>
<td>random assigned</td>
<td>6 wks; 2 × wk; 12 sessions; 80 jumps/session initial, 80 end; increase 10 jumps/wk</td>
<td>n = 12 17.3 ± 0.4 yrs males</td>
<td>speed, agility, vertical jump</td>
<td>baseline, post training</td>
<td>CMJ, DJ, vertical jump ↑4 %, agility time ↑2-7 %, P &lt; 0.05</td>
</tr>
<tr>
<td>Kotzamanidis 2006</td>
<td>PT on running performance and vertical jumping</td>
<td>quasieperimental conveniences sample</td>
<td>10 wks; 2 × wk; 20 sessions; 60 jumps/session initial, 92 end; increase 12 jumps/wk</td>
<td>PTG n = 15 11.1 ± 0.5 yrs males</td>
<td>SJ, speed</td>
<td>baseline, post training</td>
<td>PTG: running velocity 0-30 m, 10-20 m, 20-30 m ↑, jump performance ↑, P &lt; 0.05</td>
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</table>
After the literature review, were selected 9 studies which judged to be of low quality across to PEDro scale. The mean rating of this scale for the studies was 4.56 out of 10 and ranged from 3 to 6 (Table 1).

**Effectiveness of plyometric training for improving performance**

All the studies (Buchheit et al., 2010; Diallo et al., 2001; Kotzamanidis, 2006; Meylan and Malatesta, 2009; Thomas et al., 2009; Rubley et al., 2011; Marques et al., 2013; Michailidis et al. 2013; Sohnlein et al., 2014,) found statistically significant effects of improving motor performance after a plyometric training program. Seven studies (Buchheit et al., 2010; Diallo et al., 2001; Kotzamanidis, 2006; Meylan and Malatesta, 2009; Marques et al., 2013; Michailidis et al. 2013; Sohnlein et al., 2014) measured the ability of speed and found statistically significant improvements (Table 2). Some researchers mentioned the effect sizes and some others provided sufficient data to calculate effect size. Sohnlein et al. (2014) and Meylan and Malatesta (2009) had large effect sizes ($d = 1.4$ and $d = -1.28$, respectively). Kotzamanidis (2006) had a moderate effect size ($d = -0.75$), and Buchheit et al. (2010) and Thomas et al. (2009) had small effect sizes ($d = 0.21$ and $d = -0.37$, respectively).

All the studies measured the ability to jump and found statistically significant improvements in jumping ability. Five of these studies (Kotzamanidis, 2006; Meylan & Malatesta, 2009; Thomas et al., 2009; Rubley et al., 2011; Sohnlein et al., 2014) had large effect sizes ($d = 2.1, 1.1, 2.2, 2, 1.1, 1.41, 2.1$, respectively) and one study (Buchheit et al., 2010) had a small effect size ($d = -0.38$). One study (Michailidis et al., 2013) measured leg strength outcomes and demonstrated statistically significant improvements. Outcomes for kicking performance were measured in 3 studies (Rubley et al., 2011; Marques et al., 2013; Michailidis et al., 2013). All of them demonstrated a statistically significant improvement. Only Rubley et al. (2011) provided sufficient data to calculate effect size which was large ($d = 2.62$).

Four studies (Meylan & Malatesta, 2009; Thomas et al., 2009; Michailidis et al., 2013; Sohnlein et al., 2014) measured agility outcomes and all the researchers mentioned statistically significant improvements. Three of the studies had large effect sizes (Sohnlein et al., 2014, $d = 1.3$, Thomas et al., 2009, $d = 1.3$, Meylan & Malatesta, 2009, $d = -2.15$).

**Exercise dosage**

When we compare a plyometric training program we have to check some characteristics like the duration of the program, the frequency, the number of jumps, the kind of jumps, and the method for increasing training volume. The duration of the plyometric training programs varied across studies from 6 to 14 weeks. Independently from the duration all the researchers mentioned significant improvements of motor performance (speed, agility, jumping ability).

The sessions per week varied across studies from once a week to 3 times a week. Buchheit et al. (2010) and Rubley et al. (2011) exercised children once a week for 14 and 10 weeks respectively and they found significant improvements. The most of the studies (Kotzamanidis, 2006; Meylan & Malatesta, 2009; Thomas et al., 2009; Marques et al., 2013; Michailidis et al., 2013; Sohnlein et al., 2014) exercised children twice a week. Three times a week used only by Diallo et al. (2001).

Another important characteristic of training is the kind of jumps. Hopping exercises and depth jumps belongs to the group of plyometric exercises. If we want to compute the intensity of a training program we have to know the kind of jumping exercises (height of jumps). In the most of the studies did not include enough information’s about this aspect, so we did not discuss the kind of jumps.

The number of jumps is another one training characteristic. Rubley et al. (2011) had used a low number of jumps per session (16 initial, 60 end) in comparison with all the other studies (from 50 initial to 350
end). In a later study, Sohnlein et al. (2014) began at 112 jumps per session and increased 15 repetitions a week to approximately 350 jumps per session by the end of the intervention. This study showed large effect sizes on running, jumping and agility such as the studies by Kotzamanidis (2006), Meylan and Malatesta (2009) and Thomas et al. (2009). Small size effect showed by Buchheit et al. (2010), and Rubley et al. (2011). These researchers did not include data for the number of jumps.

**Discussion and Conclusion**

This review showed that young soccer players may be benefited from a plyometric training program that is integrated with their usual soccer practice routine by improving motor performance parameters. In all studies the researchers observed significant improvements at the performance characteristics that they study.

In two studies (Michailidis et al., 2013; Sohnlein et al., 2014) the participants in CG demonstrated significant improvements in speed and in one study (Sohnlein et al., 2014) the improvement in MB5 was statistically meaningful. Buchheit et al. (2010) mentioned that the group of repeated shuttle sprint training had improved at the tests of CMJ and hopping test. In this study the shuttle sprint group performed a kind of exercise that enhances the leg power. Sprint with change of direction is a strong stimulus for the improvement of this kind of power. The lack of changes in all the other motor performance characteristics in participants of CG demonstrates the significance of plyometric training incorporation in regular soccer practice to enhance lower leg power performance in young soccer players.

In all studies the participants were children. Only in the study of Thomas et al. (2009) the average age was 17.3 years. From the rest studies three performed to prepubertal children (< 12 years) and five to pubertal children. Eight studies performed to males and one (Rubley et al., 2011) to young female soccer players. Independently of the gender all the researchers mentioned significant improvements of motor performance.

Vertical jump elevation mentioned from all the researchers. The adaptations in children after plyometric training are likely to be more neural in nature because of the children’s limited potential to increase their muscle strength and size because of their low testosterone levels. Also this kind of training (plyometric) has been shown to be related mainly to neural adaptations (Baker, 1996). Literature review showed that plyometric training improves the performance in all types of jumps (CMJ, SJ, DJ, MB5).

One index that measured by the most of the researchers was the speed. Sprint performance characterized by 3 phases (Delecule et al., 1995): a) initial acceleration (0-10 m), b) secondary acceleration (10-30 m) and c) maximal velocity phase (after 30 m). Nevertheless the duration of the second or third phase may be dependent on gender and performance level (Delecule et al., 1995). In children maximal velocity develops at 20-30 m (Delecule et al., 1995; Kotzamanidis, 2006). Literature review showed that the effectiveness of plyometric training on young soccer players produced contradictory results. Michailidis et al. (2013) mentioned that plyometric training elicited a marked improvement of all sprinting phases. Meylan and Malatesta (2009) reported that sprint time improved after training program. Thomas et al. (2009) reported a lack of change in sprint performance after plyometric training. Also the discrepancy between the studies may be attributed to differences in the participants’ conditioning level and the variation in quantity and quality of training. It has been shown that trained boys are more responsive to various training stimuli than their untrained counterparts in terms of speed improvement (Mero et al., 1991). The improvement of speed performance in CG suggesting that soccer practice alone may contribute to speed development probably because of the high frequency of short maximal sprints incorporated in this type of practice.

Leg strength measured only by Michailidis et al. (2013) and they found that a 12 week plyometric training program resulted in a modest increase of leg strength. Probably this kind of exercises might have induced an upregulation of motor unit recruitment and inhibition of protective antagonist muscle action. As we mentioned above this improvement be attributed to neuromuscular adaptations.

In four studies (Meylan and Malatesta, 2009; Thomas et al., 2009; Michailidis et al., 2013; Sohnlein et al., 2014) the researchers performed a kind of agility test and they mentioned significant improvements. The characteristics of an agility test are the change of direction, with decelerations and accelerations. These elements correlated with lower limp muscle power (Negreteand Brophy, 2000; Young et al., 2002).

Kicking distance or velocity was also improved by plyometric training in three studies (Rubley et al., 2011; Marques et al., 2013; Michailidis et al., 2013) This improvement may be attributed to the increased strength and power of the leg muscles.
When initiating an exercise intervention for children we have to care about safety. In the most of the studies the plyometric training programs were part of the total soccer training, with short duration, included a warm up and cool down protocol. Also the participants before execute the exercises, had to learn the correct technique. If the instructors and children follow safety guidelines the plyometric training is safe for them.

In conclusion after the literature review we can suggest that children demonstrate considerable plyometric trainability as evidenced by the marked improvement of speed, jumping ability, strength, and agility and kicking performance. It is needed more research to identify the physiological mechanisms responsible for these performance gains.

From the results of the literature review we can say that plyometric training programs are effective for improving motor performance in young soccer players between 10 and 17 years of age. Training effects can be achieved with a twice a week program for 8 to 10 weeks. Exercise load should be increased progressively weekly. For the volume of training we have to take care about the intensity (height) and the number of the jumps. A number of 50-60 jumps the first week and progress to 100-120 by the end will be effective.

**Conflict of interest**

The authors declare no conflict of interest

**References**


