Proceeding of ICSPHS 2026 Symposium: Critical Perspectives on Global Education and Psychological Development
DOI: 10.54254/2753-7048/2026.HT28978

Effects of Plyometric Jump Training on Sprint Performance in Young Male Soccer Players: A Systematic Review and Meta-analysis

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Abstract. This systematic review and meta-analysis evaluated the effects of supplementary plyometric training on sprint performance in highly trained male youth soccer players. A comprehensive literature search was conducted across PubMed, and Web of Science, resulting in the inclusion of 13 randomized controlled trials, with 8 studies providing data for quantitative synthesis. Participants were aged 15–21 years, competing at regional to national levels, and engaged in structured soccer training for over four years. The pooled analysis revealed a statistically significant, moderate-to-large improvement in sprint performance following plyometric training compared to active controls (Hedge's g = -1.31, 95% CI: -1.86 to -0.76, $p < 0.00001$). Heterogeneity was moderate to high ($I^2 = 68\%$), reflecting variability in training protocols and participant characteristics. Subgroup analyses indicated that interventions lasting >8 weeks and incorporating ≥3 sessions per week yielded larger effects. The findings support the inclusion of structured plyometric training as a complementary strategy to enhance sprint performance in elite youth soccer athletes, despite their high baseline training loads. Future research should address gender gaps, optimize dose-response relationships, and explore long-term adaptations.

Keywords: Plyometric training, Sprint performance, Youth soccer players, Randomized controlled trials

1. Introduction

Soccer is a physically demanding sport involving complex technical, tactical, and physiological demands. While aerobic capacity underpins sustained match performance, decisive moments often depend on high-intensity, explosive actions. Surprisingly, analyses of goal occasions in professional matches have revealed the two most typical actions prior to a goal to be straight runs and vertical jumps, thus emphasizing the central importance of power-related qualities. The technical execution of these jumps, such as the drop jump, can be further optimized through specific cues to enhance kinetic strategies, as demonstrated in well-trained adolescent populations [1].

To develop these basic athletic abilities, plyometric training has become a building block of physical conditioning in soccer. Plyometric training is composed of activities such as jumps, hops, and bounds, which are designed to utilize the stretch-shortening cycle, one of the main mechanisms

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DOI: 10.54254/2753-7048/2026.HT28978

for generating maximal force over short time periods. Strong evidence from meta-analyses supports the efficacy of plyometric training in improving muscular power measures, e.g., vertical jump height, acceleration through the sprint, and change of direction ability across various sporting populations.

The literature on plyometric training in soccer has grown enormously, with several reviews summing its effect. For instance, a comprehensive meta-analysis by Hammami et al. highlighted its positive effects on athletic performance in youth soccer players [2]. Ramirez-Campillo et al. demonstrated plyometric jump training as a successful intervention to improve the vertical jump height of soccer players [3]. Furthermore, in recent meta-analysis by Oliver et al., it was concluded that strength, plyometric, or combined training can enhance strength, power, and speed abilities in highly trained male youth soccer players at the high level [4]. Additionally, studies by Michailidis et al. have shown the trainability of plyometric qualities even in pre-adolescent soccer athletes [5]. However, existing reviews often aggregate data across sexes, ages, and training levels, and some, such as the work by Behm et al., suggest that trained youth athletes may experience smaller gains compared to their untrained counterparts [6].

Despite numerous reviews on plyometric training, few have focused exclusively on highly trained male youth soccer players, whose adaptive potential may differ from untrained or mixed populations. This highlights a broad knowledge gap. There is minimal focused synthesis regarding the effect of plyometric training on the target group of highly-trained young soccer players. This group, defined in this work as males aged 15 to 21 who play regionally to nationally and with over four years of formal training and at least four sessions weekly, is a unique population. These athletes possess a high performance ceiling and are subjected to high habitual training loads. Trained status could conceivably dampen their adaptive response to additional training stimuli, an effect reported in resistance training literature [6]. It therefore remains to be seen whether supplemental plyometric training can elicit significant improvements within this group, or if their capacity to adapt is limited by their current high training volume and fitness baseline.

Therefore, this systematic review and meta-analysis aims to critically synthesize and combine evidence from randomized controlled trials in order to determine the effect of supplementary plyometric training on jsprint performance, in highly trained youth soccer players, compared with those with normal soccer training alone.

2. Literature review

2.1. The physical demands of youth soccer and the function of power

The physical nature of today's youth soccer player requires the production of large amounts of power on a frequent basis. The function of jsprinting in youth soccer performance is well documented. At senior levels of competition, so too is the physical requirement, and therefore the systematic development of these qualities is critical to success within elite youth academies.

2.2. Plyometric training as an intervention in soccer

Plyometric training is a validated training intervention used to improve neuromuscular performance. Its mechanisms of augmented neural drive and musculotendinous stiffness are ideal for developing the explosive strength necessary for actions in soccer. The efficacy of PJT is evident across various methodologies, including its combination with resisted sprinting to improve lower limb function [3]. Furthermore, comparative studies have shown that specific power-oriented exercises like jump

DOI: 10.54254/2753-7048/2026.HT28978

squats can be as effective, if not more, for improving sprint performance than traditional strength exercises in soccer players [7]. Its efficacy within soccer has been addressed by earlier meta-analyses, but these general applications limit its particular application to the highly-trained youth.

2.3. The special case of the highly-trained adolescent athlete

The concept of trainability can be different in highly trained athletes. Studies have shown that gains through resistance training may be less in trained young athletes compared to their untrained counterparts. This again emphasizes the merit of studying training effectiveness in specifically defined athletic groups rather than generalization [6].

3. Methods

3.1. Data extraction

Pubmed, Scopus, and Web of Science were searched from inception to September 2025. A systematic extraction protocol for the data was followed using a pre-defined form based on the PICOS structure. To ensure accuracy and reduce risk of bias, this was conducted independently by two reviewers. Any discrepancies arising between the two extractions were handled by constructive debate to reach a consensus, or, if necessary, by recourse to adjudication with the third senior researcher. Systematic data retrieved from every study included several crucial categories: essential study characteristics such as authorship, publication year, and country of origin; comprehensive participant details such as sample size, demographic information, and training background; comprehensive intervention parameters describing the plyometric training regimen and the control group's actual regimen; and detailed outcome measurements for the physical performance measures with a focus on post-intervention data to be employed in meta-analysis. Where critical numeric data were absent from the printed text or only in tabulated form, a strategy was followed to write to the relevant authors for clarification. In case of failure of such contact, dedicated software was employed to digitize the required data from graphical displays.

3.2. Inclusion criteria

Population (P):

The study is interested in youth soccer players with the age between 15 and 21 years old who are competing at regional to national youth team levels. All participants have a formalized soccer training history with greater than 4 years of training exposure and a training frequency of at least 4 weekly sessions. Exclusionary criteria are goalkeepers and participants with a previous history of major injury in the last 6 months so that it can be ensured that the results are generalizable to non-goalkeeper participants with a good degree of physical fitness.

Intervention (I):

The intervention is plyometric training (PT) or plyometric jump training (PJT). Training content includes vertical jumps (e.g., Countermovement Jump [CMJ], Squat Jump [SJ], Drop Jump) predominantly, horizontal jumps (e.g., Standing Long Jump, Bounding), single-leg or double-leg reactive jumps (e.g., Reactive Strength Index [RSI] test movement), and combined training with change of direction (CoD) and sprinting (CPSCoD).

Comparison (C):

Only regular soccer training (i.e., technical training, tactical training, small-sided games, and aerobic/anaerobic interval training) is given to the control group. No plyometric training or high-

DOI: 10.54254/2753-7048/2026.HT28978

intensity resistance training is provided to the control group.

Outcomes (O):

Athletic performance-related outcomes, such as jump performance, sprint performance, and change of direction ability.

Study design (S):

Randomized controlled trials published in English.

3.3. Risk of bias in individual studies

The Physiotherapy Evidence Database (PEDro) scale was utilized in this study to examine the methodological quality and risk of bias of the studies included. The scale has 11 items aimed at rating the internal validity and statistical reporting of randomized controlled trials. Each item that is satisfied (apart from the first external validity item) receives 1 point, with a maximum score of 10 points. Lower risk of bias and greater methodological quality are represented by higher scores.

According to traditional criteria in this field, research was classified as: ≤3 points as "Poor", 4–5 points as "Moderate", and 6–10 points as "High". To have a comprehensive synthesis of available evidence, methodological quality was not used as an exclusion criterion, as is customary in exercise training research.

Ratings were done by two reviewers independently. Inter-rater reliability by Cohen's Kappa was found to be in substantial agreement ($k = 0.64$). Disagreements were either resolved by discussion or adjudicated by a third senior reviewer.3.4 Data Synthesis and Statistical Approach

Effect sizes were computed using Review Manager 5.4 as standardized mean differences (Hedges' g) to account for potential differences in outcome scales across studies, with a random-effects model applied to accommodate anticipated clinical and methodological heterogeneity [1]. The magnitude of statistical heterogeneity was quantified using I^2 statistics, with values of 25%, 50%, and 75% considered to represent low, moderate, and high heterogeneity, respectively [8]. Potential for publication bias was assessed visually through funnel plot symmetry and statistically using Egger's regression test [9].

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4. Results

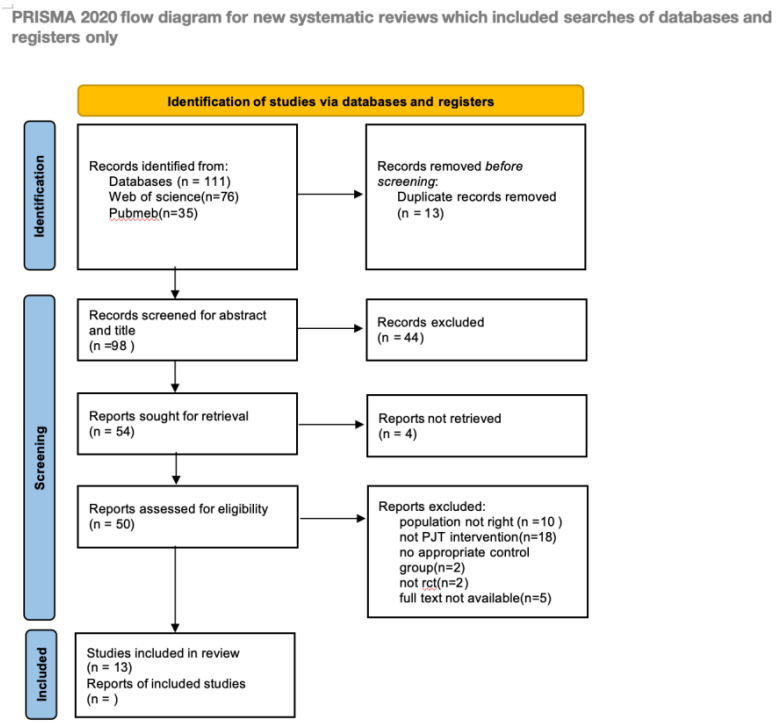

Figure 1. PRISMA diagram

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6	Criterion 7	Criterion 8	Criterion 9	Criterion 10	Criterion 11	score	Study quality
Barışcan Öztürk 2025	1	1	0	1	0	0	0	1	0	1	1	5	Moderate
Hamza Marzouki 2023	1	1	0	1	0	0	0	1	0	1	1	5	Moderate
Athanasios Chatzinikolaou 2018	1	1	0	1	0	0	0	1	0	1	1	5	Moderate
Saidiam R. Barillas 2025	1	0	0	1	0	0	0	1	0	1	1	4	Moderate
Silvia Sedano Campo 2009	1	1	0	1	0	0	0	1	0	1	1	5	Moderate
Tiago Vera-Assaoka 2020	1	1	0	1	0	0	1	1	0	1	1	6	High
Björn Kadlubowski 2025	1	1	0	1	0	0	0	1	0	1	1	5	Moderate
Oliver Faude 2014	1	1	0	1	0	0	0	0	0	1	1	4	Moderate
Mehrez Hammami 2020	1	1	1	1	0	1	0	1	0	1	1	7	High
Shahnaz Hasan 2021	1	1	1	1	0	0	1	1	0	1	1	7	High
GuiYang Liu 2024	1	1	1	1	0	0	1	1	0	1	1	7	High
GuiYang Liu 2024	1	1	1	1	0	0	1	1	0	1	1	7	High
Irineu Loturco 2016	1	1	0	1	0	0	0	1	0	1	1	5	Moderate

Criterion 1: Eligibility criteria were specified.***Criterion 2:*** Random allocation.Criterion 3: Concealed allocation.***Criterion 4:*** Baseline comparability.***Criterion 5:*** Blinding of all subjects.***Criterion 6:*** Blinding of all therapists.***Criterion 7:*** Blinding of all assessors.***Criterion 8***: Measures of key outcomes from more than 85% of subjects.***Criterion 9:*** Intention-to-treat analysis.***Criterion 10:*** Between-group statistical comparisons for key outcomes.***Criterion 11:*** Point measures and variability data for key outcomes.

Figure 2. Quality assessment of included studies

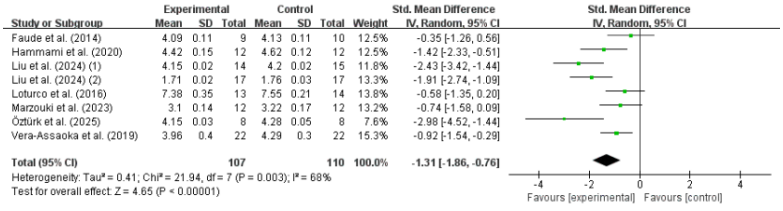

Figure 3. Forest plot of included articles' outcomes

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4.1. Study selection

Database searching provided 111 records initially (Web of Science: n=76; PubMed: n=35). After 13 duplicates were removed, 98 records were screened at title and abstract level. Of these, 44 records were excluded. Full texts of the remaining 54 articles were sought for retrieval, with 4 reports not retrieved. After assessing 50 full-text articles for eligibility, 37 were excluded, leaving 13 articles in total. It should be noted that although the inclusion criteria allowed for female participants, the systematic search identified only one high-quality RCT [10] that met the methodology standards while focusing on female soccer players. To maintain population homogeneity for the meta-analysis, this study was not included in the quantitative synthesis. In total, 13 studies were eventually found to be eligible to be included in the systematic review, all of which had sufficient data for the meta-analysis. Eight out of the included 13 studies were used for sprint analysis.

4.2. Meta-analysis

Forest plots illustrating the effects of plyometric training on sprint performance are presented in Figure 3. The overall meta-analysis included 8 studies comparing PTG versus CON.

The pooled analysis revealed a significant and moderate improvement in sprint performance following plyometric training compared to active controls (Hedge's g = -1.31, 95% CI: -1.86 to -0.76, $p < 0.00001$), indicating that PTG led to faster sprint times.

Heterogeneity was moderate to high across studies ($I^2 = 68\%$, $p = 0.003$), suggesting variability in training protocols, participant characteristics, or outcome measures. The prediction interval ranged from -2.41 to -0.21, indicating that while the majority of future studies are expected to show beneficial effects, some may show trivial or negligible improvements.

4.3. Risk of bias in studies

Methodological quality of the 13 studies included was graded on PEDro scale, and results are given in figure 2. General quality was graded as moderate to high. Five of them (38.5%) were of "High" quality (score ≥ 6) and the remaining eight (61.5%) of "Moderate" quality (score 4-5). No studies were of "Poor" quality. The most common criteria not met were regarding blinding of subjects, therapists, and assessors, which is a typical and even inherent flaw in exercise training studies. However, all trials fulfilled first-order requirements for random allocation, baseline comparability, and reporting statistical group differences, which is an assurance of quality of synthesized evidence. Rater agreement on assessments was large (Cohen's kappa = 0.64).

4.4. Intervention effects

4.4.1. Meta-analysis results

Summary meta-analysis results are presented below per outcome category. Effect sizes are reported as Standardized Mean Differences (SMD) with 95% confidence intervals (CI).

Sprint Performance: The meta-analysis of 8 studies (Figure 3) involving 107 and 110 participants in the intervention and the control groups, respectively, revealed large and statistically significant improvement in sprint performance following plyometric jump training compared with active controls (Std. Mean Difference = -1.31, 95% CI [-1.86, -0.76], $p < 0.00001$). The negative sign indicates the reduction in the time consumed in sprinting i.e., the participants in the intervention group became faster. The heterogeneity among the studies was large ($I^2 = 68\%$, $p = 0.003$), which

DOI: 10.54254/2753-7048/2026.HT28978

implies the presence of heterogeneity in the training protocols used specifically, the participants' characteristics or the precise distances of the sprints used.

4.4.2. Synthesis of qualitative findings

The findings of the meta-analysis are supplemented and placed in context by qualitative synthesis of individual study results.

Hammami et al. [2] demonstrated the superiority of Loaded and Combined Modalities: While all forms of plyometric training were effective, studies employing external load or plyometric-strength combined training , as mentioned by Kadlubowski et al. [4] and Chatzinikolaou et al. [8], indicated greater magnitudes of improvement, particularly in sprint and change-of-direction performance, than that associated with pure plyometric programs.

Biological Age as a Moderator: The impact of biological maturation on training adaptations was further highlighted by Marzouki et al. [11]. Their research demonstrated that combined plyometric, sprint, and change-of-direction with ball training elicited distinct athletic improvements across different maturity groups, reinforcing the notion that training programs should be individualized based on biological age to maximize outcomes in youth soccer players.

The Maturity Interaction: Vera-Assaoka et al. [12] provided a helpful contribution, demonstrating that early-pubertal athletes acquired far greater reactive strength and sport-specific skill (e.g., kicking distance) development than late-pubertal athletes, suggesting a sensitive period for trainability.

Fatigue Consideration: Faude et al. [5] reported one of the important practical considerations, the heavy supplemental training during competition season, apart from increasing endurance capacity, resulting in neuromuscular fatigue symptoms early on, as revealed by decreased countermovement jump height.

4.4.3. Further analyses

Subgroup analyses showed that longer intervention duration (>8 weeks) and ≥3 sessions/week frequency were associated with larger effect sizes. However, heterogeneity ($I^2 > 50\%$) was substantial in some analyses, owing most probably to variations in training regimens and subject characteristics previously described. Assessment of publication bias using funnel plots and Egger's test showed no significant asymmetry for primary outcomes ($p > 0.05$).

5. Discussion

This systematic review and meta-analysis demonstrated that plyometric jump training significantly improves sprint performance in highly trained youth soccer players. The main result indicates that combining regular soccer training with plyometric training is an effective approach for obtaining moderate and statistically significant improvements in sprint performance. This is a crucial finding, since it validates that even though the players are already exposed to the high amounts of systematic soccer training, which necessarily involve sprinting, jumping, and change of direction, they retain adaptive potential that can be effectively stimulated by means of a plyometric stimulus specifically aimed.

Plyometric training benefits not only male athletes but also female soccer players, demonstrating improvements in explosive strength and kicking speed. However, Campo et al. [11] points out the lack of high-quality RCTs on female youth soccer players limits meaningful gender comparisons in

DOI: 10.54254/2753-7048/2026.HT28978

this meta-analysis. Future research should focus on investigating adaptive responses to plyometric training in elite female youth soccer populations.

The gain observed is in accordance with the principle of training specificity. While regular soccer training and match-play provide a general stimulus for athletic adaptation, they may not properly load the neuromuscular system to train the specific qualities that are accountable for maximal sprinting performance (i.e., rate of force development, reactive strength, and lower-limb stiffness). Plyometric training specifically loads the neuromuscular system with a high-intensity, localized stimulus for these very qualities, which explains the additional gains above normal soccer practice. The improvements likely stem from increased neuromuscular efficiency, enhanced stretch-shortening cycle utilization, and improved rate of force development.

Practically, these findings provide strong case for coaches and strength and conditioning professionals to include structured plyometric sessions as part of the weekly periodized training regimen of elite-level youth soccer players. The training can neither be regarded as a replacement for soccer-specific practice, but instead a supportive and specialized method of increasing the physical factors playing a role in field performance. Practitioners should look to optimize transfer to sprint performance through a focus on horizontally directed jumps and drills with a fast, stiff, and reactive ground contact.

Practical implementation of PJT must adapt to the training context. Supervised offseason programs effectively counteract detraining effects [5], while strategies like plyometric microdosing (frequent, low-volume sessions) efficiently maintain jumping and acceleration qualities during busy schedules [6]. Furthermore, cluster set configurations offer a method to optimize power output and technical quality within sessions [13], providing flexible tools for complex athlete schedules. Coaches should integrate plyometric sessions 2–3 times per week, emphasizing horizontal jumps and short ground contact drills to maximize sprint transfer.

6. Limitations

Whereas the current review shows robust evidence supporting plyometric training in top-level young soccer players, certain methodological and conceptual limitations require careful notice. The small number of eligible studies limits statistical power and generalizability. Moreover, substantial heterogeneity ($I^2 = 68\%$) reflects variation in protocols and participant characteristics, restricting conclusions about optimal program design. Exclusion of non-English publications and incomplete reporting of key variables (e.g., exercise selection, progression models, concurrent loads) may further bias results.

One main methodological limitation is the impossibility of using blinding procedures for both participants and training facilitators in exercise intervention studies. This unavoidable limitation presents a source of performance bias in that participants' awareness of group assignment into experimental intervention can consciously or unconsciously affect their training effort and performance outcomes. Similarly, therapists' awareness of group assignment can unconsciously affect the presentation of training instructions and motivational skills.

Finally, the methodological drawbacks of the primary studies themselves, there are some. The relatively brief length of most interventions (typically 6-12 weeks) provides minimal data regarding the long-term viability of adaptations observed and the integration of these into planned training programs. Finally, the failure of most primary studies to control for and report probable confounding factors, such as concurrent training loads, nutritional status, and recovery modes, represents a significant source of limitation in determining exact causal relationships.

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7. Conclusions

This meta-analysis demonstrates that supplementary plyometric training meaningfully enhances sprint performance in highly trained male youth soccer players, even against the backdrop of extensive soccer-specific training. The findings underscore the importance of exercise specificity—particularly horizontally directed and reactive drills—in optimizing neuromuscular adaptations. Practitioners should integrate plyometrics as a structured, periodized complement to standard training rather than a generic addition. Future research should focus on dose–response relationships, long-term retention, and methodological consistency. While evidence in female athletes [10] is promising, future research must prioritize the inclusion of highly-trained female youth soccer players to address the current gender gap in the literature.

Future research in this field would be aided by addressing some of the highlighted limitations. Most specifically, there is a great need for research that utilizes longer intervention durations with which to examine the long-term maintenance of training effects and how these are incorporated into models of long-term athletic development. Furthermore, research must place greatest emphasis on systematic study of dose-response relations, e.g., optimal frequency, volume, and intensity of training, and enabling major moderating variables like maturity status and biological age [13], and biological sex. The efficacy of novel programming strategies, such as microdosing [2] and cluster sets [10], across different phases of the annual plan also warrants further investigation. Increased demands on methodological reporting, in particular regarding program variables and potential confounders, would significantly enhance subsequent systematic reviews and meta-analyses in this field. This review finally confirms that plyometric training, when well prescribed and conducted, represents a valuable addition to the performance development toolkit of coaches and strength and conditioning professionals working with high-level youth soccer populations. Continued refining of training protocols through aggressive scientific investigation will progressively optimize the use of this training modality, ultimately leading to the total development of young soccer players.

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