Journal for Educators, Teachers and Trainers
The LabOSfor electronic, peer-reviewed, open-access Magazine

Journal for Educators, Teachers and Trainers
The PROFESIOLab electronic, peer-reviewed, open-access Magazine

ISSN 1989-9572

DOI: 10.47750/jett.2025.16.05.03

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Journal for Educators, Teachers and Trainers, Vol.16 (5)

https://jett.labosfor.com/

Date of reception: 02 April 2025

Date of revision: 01 May 2025

Date of acceptance: 02 June 2025

Islam Youcef Loukia[1], Walid Grine[2], Yacine Belfritas[3] (2025). Effect of Plyometric Training Jump Techniques on Speed and Explosive Power of Lower Limbs in Football Players. ***Journal for Educators, Teachers and Trainers, Vol.16 (5) 27-37***

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Effect of Plyometric Training Jump Techniques on Speed and Explosive Power of Lower Limbs in Football Players

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Abstract:

This study examined the effects of plyometric jump training on speed and lower-limb explosive power in football players. Twenty U21 elite male players from Algeria's Association El Khroub club were randomly allocated into an experimental group (n=10) undergoing plyometric jump training and a control group (n=10) following conventional training. Performance was assessed using the 30-meter sprint test and countermovement jump (CMJ) test. Statistical analyses included independent/paired t-tests and two-way ANOVA.

The study results revealed significant improvements in CMJ performance between pre- and post-tests ($p<0.05$; ES=0.63-1.31), with a pronounced main time effect ($p<0.05$; $\eta^2=0.693-0.935$). The experimental group demonstrated superior CMJ gains compared to controls ($p<0.05$; $\eta^2=1.31$). However, no significant 30-meter sprint enhancements were observed ($p>0.05$).

While plyometric training proves effective for developing explosive power, its speed-related outcomes require cautious interpretation due to the study's limited sample size. The variability in training responses underscores the influence of program design factors (duration, volume, intensity). These findings highlight the necessity for tailored interventions addressing sport-specific speed physiology. Further research should incorporate larger cohorts and extended intervention periods to validate these observations.

Keywords: Plyometric Training, jump training Techniques, speed Performance, Countermovement Jump, lower-limb Power.

Introduction

In modern football, high physiological and physical demands are essential for optimal performance across all age groups without exception adults, youth, and juniors. These demands include high-intensity movements (e.g., sprinting, jumping, cutting, changing direction, and high-speed endurance), moderate-intensity movements (e.g., jogging), and low-intensity movements (e.g., walking). These requirements are influenced by various factors, including player position, skill level, playing style, and the tactical strategies employed by the team (Impellizzeri et al., 2006). They are also affected by the level of physical preparation and the training methodology adopted. Studies have shown that high-level and elite youth players outperform their lower-level counterparts in jumping and sprinting performance, underscoring the importance of developing these attributes (Vaeyens et al., 2006).

Furthermore, players who excel in jumping and sprinting are more likely to be selected for higher competitive levels as they transition to senior competitions. Thus, the development and enhancement of jumping and sprinting capacities should be prioritized in football training programs (Carling & Reilly et al., 2010).

The ability to sustain improvements in explosive actions during the competitive season remains a challenge for both coaches and players due to limited training time, particularly during match periods, or due to frequent injuries that hinder optimal performance. Additionally, this phase often emphasizes technical and tactical development in football.

Plyometric exercises are commonly used to enhance explosive actions in both adult and pre-adolescent football players (Michailidis et al., 2013) and are among the most effective training methods for maintaining physical performance levels. Meylan & Malatesta (2009) demonstrated that high-intensity plyometric training during the season (approximately 100–120 ground contacts per session) can improve explosive performance. Overcoming external resistance relies on muscular contraction, which is linked to the ability to generate maximal force in the shortest possible time a quality known as explosive strength. This refers to a player's capacity to produce peak force rapidly.

Lower-body strength, particularly vertical jump performance, is a fundamental component of successful athletic performance. Numerous studies have focused on improving vertical jump performance as a means of enhancing players' explosive power. Similarly, enhancing sprint performance is beneficial for various sports for multiple reasons. Short-distance sprinting is highly significant in many sports, with elite football players spending approximately 11% of match time sprinting equivalent to covering 10–15 meters every 90 seconds (Bangsbo & Mohr et al., 2006). For instance, sprint duels enable players to reach the ball before opponents, exploit open spaces, evade with or without the ball, and execute rapid changes of direction and maneuvers. Therefore, coaches must develop these physical attributes to help players meet the increasing competitive demands of modern football.

Plyometric training refers to exercises designed to enhance muscular power. These exercises include various forms of jumping such as hopping, bounding, and box jumps as well as depth jumps and hurdle jumps. The core principle of this training method is conditioning the neuromuscular system to adapt more quickly to changes in force levels, particularly during explosive movements like jumping (upward or downward) combined with sprinting and directional changes.

characteristic of plyometric exercises is the eccentric (lengthening) contraction of the muscle-tendon unit, immediately followed by a concentric (shortening) contraction a mechanism known as the stretch-shortening cycle (SSC).

This article highlights the effects of plyometric training on speed and explosive power of the lower limbs, primarily through the use of various jumping exercises (horizontal, vertical, and lateral).

- **Materials and methods**

- ***Study participants***.

Twenty U21 senior soccer players from the Algerian club *Association El Khroub* in Constantin province, which competes in the local second division, voluntarily participated in this study. All participants were free from injuries and illnesses. The researchers explained the study's objectives, duration, equipment used, and potential risks to the players. All players provided prior consent to participate. This study adhered to the principles of the Helsinki Declaration (World Medical Association, 2013).

Participants were randomly divided into two groups: the experimental group and the control group, with 10 players each. Table 1 displays the participants' characteristics.

Table 1. Participants' characteristics

Variables	**Experimental group (n=10)**	**Control group (n=10)**	**p- values**
	Mean ± SD		**0.05**
Age (year)	19.50 ± 0.70	19.80 ± 0.42	0.264
Height (cm)	177.5 ± 4.30	176.8 ± 5.78	0.446
Body mass (kg)	72.7 ± 4.34	71.30 ± 3.65	0.762
BMI (kg/m^2)	23.05 ± 0.30	22.82 ± 0.85	0.439

No differences between groups were observed in these variables. SD: Standard deviation; BMI: Body Mass Index; m: meter; Kg: Kilogram; Kg/m^2: Kilogram/meter^2, and. $p>0.05$

- ***Design and procedures***.

This experimental study was conducted to examine the effect of plyometric training jump techniques on speed and explosive power of the lower limbs in U21 soccer players. The sample consisted of 20 players who were randomly divided into two groups: a control group and an experimental group.

The study began in September 2024, precisely during the physical preparation phase, where anthropometric measurements (height, weight, body mass) and chronological age were collected. Subsequently, baseline tests (pre-tests) were administered to both the control and experimental groups.

During the study period, plyometric training exercises (including various vertical, horizontal, and lateral jumps) were incorporated into the training sessions of the experimental group at a rate of two sessions per week for 8 weeks. Meanwhile, the control group adhered to a traditional training program. Identical warm-up routines, and proprioceptive exercises, and technical-tactical drills were applied to both groups throughout the study.

The independent variable in this study was plyometric training techniques, while the dependent variables included both speed and explosive power of the lower limbs.

- ***Assessment.***

Anthropometric measure: anthropometric measurements included height and body mass, which were recorded using a stadiometer and commercial scale (accu- measure digital scale) body mass index (BMI) was calculated as body weight (in kilograms) divided by height (meters) squared.

Assessment of speed: assesses speed, the 30-meter test was used. In this test players have to run as fast as possible from the starting line to the finish line. This test is valid, reliable, and widely used to assess linear speed in soccer (Altmann et al., 2019). Two maximum attempts were allowed for each player, and the best attempt was considered for analysis.

Assessment of explosive power: This study utilized the My Jump 2 mobile application to evaluate players' countermovement jumps (CMJ). This test serves as a crucial tool for assessing lower-limb muscle strength, power, and coordination. The test demonstrates high reliability, and the application offers a cost-effective, user-friendly solution. (Peng et al, 2024)

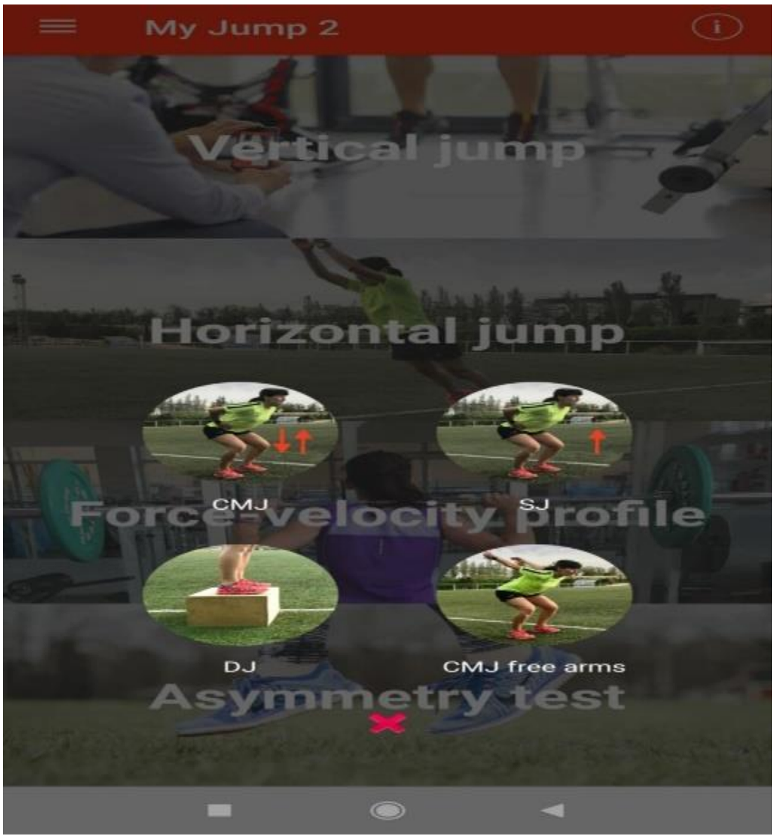

Figure 1. CMJ. test by my jump 2 appl.

- ***Training program.***

Both the control and experimental groups trained simultaneously at the same artificial grass pitch. The experimental group followed a plyometric training program consisting of various jump exercises (vertical, horizontal, and lateral). Prior to jump training, proprioceptive exercises were conducted to activate target muscles and prevent jump-related injuries.

The program spanned eight weeks with two sessions. Training load was progressively increased by adjusting hurdle height and number of repetitions. Meanwhile, the control group maintained their coach-prescribed training regimen which excluded jump-specific exercises.

Table 2. Training program content

Week	Session	Total foot contacts.	Exercises.
1	2	50- 70	-Countermovement Jump (8 rep\ 3set) -Standing Long Jump (8 rep\ 3set) - Lateral Bound (6 rep\ 3 set)
2	2	80 -90	-Hurdle jump, 30 cm (10 rep\ 3set) - Single-Leg Hop each leg (8 rep\ 3set) - Skater Jump each side (8 rep\ 3 set)
3	2	90 -100	- Hurdle jump, 40 cm (12 rep\ 3set) - Alternate-Leg Bound (10 rep\ 3set) - Skater Jump each side (10 rep\ 3 set)
4	2	80 -120	-Tuck Jump, 40 cm (8 rep\ 3set) - Gazelle Jump (8 rep\ 3set) -Lateral Hurdle Hop (8 rep\ 3set)
5	2	90- 100	-Countermovement Jump (6 rep\ 3set) -Standing Long Jump (6 rep\ 3set) - Lateral Bound (5 rep\ 3 set)
6	2	80 -120	-Hurdle jump, 40 cm (8 rep\ 3set) - Single-Leg Hop each leg (6 rep\ 3set) - Skater Jump each side (6 rep\ 3 set)
7	2		- Hurdle jump, 45 cm (10 rep\ 3set)

		60 -120	**- Alternate-Leg Bound (6 rep\ 3set)** **- Skater Jump each side (6 rep\ 3 set)**
8	**2**	**60 -120**	**- Tuck Jump, 45 cm (6 rep\ 3set)** **- Gazelle Jump (8 rep\ 3set)** **-Lateral Hurdle Hop (8 rep\ 3set)**

- ***Statistical analysis.***

Data in this study were presented as mean and standard deviation (SD). The Shapiro-Wilk test was used to assess the normal distribution of the data. An independent t-test was conducted to compare the experimental and control groups in the pre-test. A paired t-test was used to compare pre- and post-test results within each group. Hedges' g effect size was calculated to determine the magnitude of the difference between pre- and post-test results, with values categorized as small (0.20), medium (0.50), or large (0.80). A two-way ANOVA was performed, considering time (pre- and post-test) and group (experimental and control) as factors. If a significant group × time interaction was observed, a Bonferroni post hoc test was applied to aid in interpreting the interactions. Partial eta-squared (η^2) was used to assess the effect size of group differences, with η^2 values classified as small (0.01), moderate (0.06), and large (0.14). Statistical significance was set at $p < 0.05$.

Results

Table 3. Comparison of Changes in 30m Speed and Countermovement Jump between experimental group and control groups.

Variables	Control group (n=10)			Experimental group (n=10)			Main time effect	Time x group
	Pre-test	Post-test	p-values [g] Magnitude	Pre-test	Post-test	p-values [g] Magnitude	p-values [η2] Magnitude	p-values [η2] Magnitude
	Mean ± SD			Mean ± SD				
30m sprint time (s)	4.93 ± 0.47	4.74 ± 0.31	**0.639** [0.47] (Medium)	4.93 ± 0.44	4.42 ± 0.11	**0.001** [1.45] (Large)	**0.003** [0.385] (Large)	**0.502** [0.025] (Small)
CMJ test (cm)	34.43 ± 1.27	35.11 ± 0.87	**0.007** [0.63] (Medium)	34.4 ± 1.22	35.80 ± 0.83	**0.004** [1.31] (Large)	**0.000** [0.935] (Large)	**0.000** [0.693] (Large)

Table 3: shows that speed and Countermovement Jump significantly improved in both the experimental and control groups The main time effects ($p < 0.05$ **(0.003\0.000).** with large effect sizes (η^2 ranging from 0.385 to 0.935). However, the time × group interaction was not significant for speed ($p > 0.05$; $\eta^2 = 0.025$). In contrast, Countermovement Jump showed a significantly greater improvement in the experimental group compared to the control group ($p < 0.05$**;** $\eta^2 = 0.693$).

Discussion

Discussion

The most significant findings of this study indicate improvements in both speed and explosive power of the lower limbs among soccer players in both the control and experimental groups. However, the experimental group, which followed plyometric training, demonstrated a more pronounced effect on enhancing explosive power in the lower extremities compared to the control group that adhered to a traditional training program. In contrast, plyometric exercises did not significantly influence the development of speed. These results can be attributed to the specificity of speed training, as plyometric training primarily emphasizes vertical movements. Although the exercises incorporated various types of jumps, they did not effectively enhance players' speed.

The results of the speed test in the current study reveal that speed development is governed by multiple factors. Among the key determinants of speed are the anatomical characteristics of muscles (Potteiger et al., 1999). Muscle composition plays a crucial role, with fast-twitch fibers significantly contributing to speed development. Additionally, speed is influenced by environmental and geographical factors. Effective sprinting requires an optimal combination of biomechanical variables and external factors, such as footwear, ground resistance, and air resistance, all of which can impact players' speed development (Mero et al., 1992).

From a mechanical perspective, speed relies on horizontal force production, a finding consistent with the results of Morin et al. (2012). Studies on speed development have demonstrated that squat exercises effectively enhance sprint performance in athletes. Styles et al. (2016) reported a strong correlation ($r = 0.94$) between absolute back squat strength and sprint performance in soccer players, aligning with earlier findings by Ford et al. (1983). However, non-specific vertical jump training (e.g., purely vertical jumps) showed no transfer to sprint performance. Conversely, a study examining the effects of a 9-week combined jump and sprint training program on adolescent soccer players (aged 14–15) found that integrating plyometric exercises with sprint training improved speed, which may explain the lack of speed improvement in our study. Thus, combining plyometrics with sprint-specific drills is recommended (Sáez de Villarreal et al., 2015).

Another critical factor in speed development is the athlete’s mastery of running mechanics (stride length, arm movement). Proper technique enhances speed, and optimizing body control and balance during motion allows players to achieve higher sprinting velocities.

Although athletes and coaches continue to use plyometric exercises to improve sprint performance, limited studies have examined the effects of vertical jump-based plyometrics on sprint performance. Moreover, the findings from the few available studies on plyometrics' impact on sprinting remain inconsistent (Kotzamanidis et al., 2006).

Regarding the effects of plyometric training on explosive power in soccer players, the study results confirm that plyometrics significantly improved explosive power, as evidenced by the countermovement jump (CMJ) test—a reliable measure of explosive capacity (Markovic et al., 2007). This outcome can be explained by the unique characteristics of plyometric training, which involves rapid stretch-shortening cycles (SSCs). Plyometrics harness elastic energy stored in tendons and muscles during the eccentric (lengthening) phase and immediately release it during the concentric (shortening) phase. Research indicates that repeated SSC movements enhance the muscles' ability to convert elastic energy into explosive force, thereby increasing muscular power (Meylan et al., 2009; Matavulj et al., 2001). Furthermore, multiple studies on SSCs have demonstrated improvements in vertical jump height (Adams et al., 1992).

Another advantage of plyometric training is its positive impact on hamstring performance. A systematic review and meta-analysis by Stojanović et al. (2017) on plyometric training's effects on vertical jump performance in female athletes found that 10 weeks of plyometrics improved countermovement jump height. Comparing these findings with our study, it is reasonable to conclude that the eight-week plyometric program involving multidirectional jumps enhanced CMJ performance in our male soccer players, given the physiological differences between genders.

The current results are further supported by the effects of plyometric jumps on tendons and ligaments. A comparative study on plyometric training using two different jump techniques found that plyometric exercises stimulate adaptations in the Achilles tendon, improving force transmission to the muscles (Ramírez-delaCruz et al., 2022; Laurent et al., 2020).

Plyometric training also enhances neuromuscular coordination among the primary lower-limb muscles (e.g., quadriceps, hamstrings, glutes), thereby increasing explosive movement performance, particularly in lower-extremity power (Miyaguchi et al., 2008).

Although this study concludes that plyometric training with varied jumps improves lower-limb explosive power but not speed in soccer players, future research should investigate the efficacy of diverse plyometric jump exercises on speed development and other soccer-specific performance requirements.

Conclusions

Plyometric training serves as an effective tool for enhancing explosive performance in football players. Although no significant improvements in speed were observed, the findings of this study cannot be generalized due to the limited sample size. Moreover, the effects of plyometric training may vary considerably depending on multiple variables including program duration, training volume, and intensity. These findings suggest the need for more comprehensive and precisely tailored interventions that specifically address the physiological demands of speed development.

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