



Experimental Study on How 10 weeks of Combined Height Interval Intensity Training (HIIT) and Plyometric Training Can Affect Explosive Power in U17 Football Players

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Authors' Contribution: A – research design/planning; B – data collection/entry; C – data analysis/statistics; D – data interpretation; E – manuscript preparation; F – literature analysis/search; G – fundraising.

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Abstract

Background and Study Aim. Examining how a ten-week training program combining high-intensity interval training (HIIT) and plyometric exercise can affect explosive strength levels among under 17-year-old football players.

Material and methods. Twenty male football players from the Algerian U17 national team were randomly divided into two groups: a control group that followed standard football training (CG; n = 10, age = 15.6±0.52; height (m) = 1.732±0.055; weight (kg) = 63.5±4.9; years of experience = 14.3±4.3) and the High Intensity Interval Training group who underwent an additional weekly plyometric training session for ten consecutive weeks (HIITG; n = 10, age = 15.70±0.5; height (m) = 1.7±0.3; weight (kg) = 58.9 ± 66; years of experience = 14.3 ± 4.3). All participants were assessed by two tests: a squat jump test (to measure jump flight time) and a horizontal jump test (to calculate the highest jump).

Results. This study found that HIITG who followed a high-intensity interval training program performed better on the squat jump test (t = -4.752, p = 0.001) and the horizontal jump test (t = -3.160, p = 0.005) with a significant interaction compared to CG.

Conclusions. This study has provided valuable information for football coaches wishing to optimise vertical jump heights in high-intensity interval training (HIIT) programs aimed at improving explosive strength in players under the age of 17. The application of these results could potentially improve player performance during football matches and reduce injuries.

Key words: height interval intensity training, plyometric training, explosive force, football.

Анотація

Експериментальне дослідження того, того, як десятитижнева програма тренувань, що поєднує високоінтенсивні інтервальні тренування (BIT) та пліометричні вправи, може вплинути на рівень вибухової сили футболістів віком до 17 років

Передумови та мета дослідження. Вивчення того, як десятитижнева програма тренувань, що поєднує високоінтенсивні інтервальні тренування (BIT) та пліометричні вправи, може вплинути на рівень вибухової сили серед футболістів віком до 17 років.

Матеріал і методи. Двадцять футболістів чоловічої статі зі збірної Алжиру до 17 років були випадковим чином поділені на дві групи: контрольна група, яка мала стандартне футбольне тренування (КГ; n = 10, вік = 15,6 ± 0,52; зріст (м) = 1,732 ± 0,055; вага (кг) = 63,5±4,9; спортивний досвід = 14,3±4,3), і група високоінтенсивних інтервальних тренувань, яка проходила додаткове щотижнєве пліометричне тренування протягом десяти послідовних тижнів (BITG; n = 10, вік = 15,70 ± 0,5; зріст (м) = 1,7±0,3; вага (кг) = 58,9 ± 66; спортивний досвід = 14,3 ± 4,3). Усі учасники були оцінені за двома тестами: тестом на стрибок з присіду





(для вимірювання часу стрибка) та тестом на горизонтальний стрибок (для розрахунку найвищого стрибка).

Результати. Це дослідження показало, що ВІТГ, які слідували програмі високоінтенсивних інтервальних тренувань, показали кращі результати в тесті на стрибок з присіду ($t = -4,752$, $p = 0,001$) і тесті на горизонтальний стрибок ($t = -3,160$, $p = 0,005$) зі значною взаємодією порівняно з КГ.

Висновки. Це дослідження надало цінну інформацію для футбольних тренерів, які бажають оптимізувати висоту вертикальних стрибків у програмах високоінтенсивних інтервальних тренувань (ВІТ), спрямованих на покращення вибухової сили у гравців віком до 17 років. Застосування цих результатів може потенційно покращити продуктивність гравців під час футбольних матчів та знизити кількість травм.

Ключові слова: високоінтенсивні інтервальні тренування, вибухова сила, пліометричне тренування, футбол.

Introduction

According to Shamshuddin et al [1], football involves intermittent, dynamic and ballistic movements, requiring advanced physical qualities such as aerobic and intermittent running ability, muscular strength, speed, flexibility and adaptability [2]. In the same vein [2], noted a football game involves more than 700 explosive actions, also featuring sprints at high, full and light speed, as well as powerful moves [3, 4]. Approximately 30 to 40 sprints, tackles and jumps during a football match can be found among [5]'s study, which also included rapid changes in the direction of the ball.

Football relies on speed and strength in lower limbs and high-powered actions [6]. Explosive actions in particular are key factors for success [7], as top-level performance in football requires a mix of physical, psychophysiological and technical skills, particularly evident in small-sided matches. As a result, various alternative training methods have been proposed to enhance the physical and technical skills of young football players [8]. Reilly et al. [7], noted that the ability to perform explosive actions is imperative for junior football players as well [4].

Interval training involves performing short bursts of high-intensity workouts separated by brief intervals of rest or low-intensity exercise, depending on programmed variables including exercise mode, duration, intensity, recovery, number of periods, frequency and distribution of the training period [9]. Interval Training has been used for several decades with various purposes, such as improvements in health standards [10, 11, 12], performance, and weight loss. Two of the most popular forms of information technology are High Intensity Interval Training (HIIT) and Sprint Intermittent Training (SIT) [13]. HIIT has been used extensively to better improve the requirements of a football competition and to help to determine the team's path before entering the competition. HIIT training is defined by short bursts of vigorous activity followed by periods of rest or low-intensity recovery exercise. Typically, these

sessions last about 30 minutes, encompassing warm-up and cool-down phases [7]. During HIIT, the aim is to reach a high level of intensity, often described as "close to maximum" or within the range of 80 to 100% of maximum heart rate (HRmax) or maximum oxygen uptake (VO2max). Additionally, exercise intervals typically do not exceed 60 seconds in duration [14], and the recovery periods, which involve either low-intensity exercise or rest, can last for as long as 4 minutes [7].

High Intensity Interval Training is considered a suitable and effective method of exercise because it offers an efficient means to enhance desired physical attributes [2]. In football games, a combination of endurance, strength, aerobic, and anaerobic capacities is crucial [15]. The primary benefit of HIIT lies in its potential to offer a more time-effective approach to attaining the desired outcomes of exercise training. [14] founded a significant improvement can be observed in muscle redox capacity, various markers of cardiovascular health, if Research three 10-minute sessions per week involving brief intervals lasting around 20 seconds.

Considering the inconsistent and scarce data from previous studies, we chose to investigate the effectiveness of combining HIIT with plyometric exercises on explosive power among young football players. Our objective was to assess how such a combined approach would influence metrics crucial to football performance, like vertical and horizontal jumps. We hypothesized that a 10-week period of combined HIIT and plyometric training would result in improvements in vertical and horizontal jumps among male U17 soccer players.

The purpose of this study is to investigate the associations between HIIT with plyometric exercises. Our objective was to assess how such a combined approach would influence metrics crucial to football performance, like vertical and horizontal jumps.

Material & Methods

Participants

As shown in Table 1, Twenty male football players from the Algerian U17 national team were randomly divided into two groups. Control group (CG; $n = 10$, age (years) = 15.6 ± 0.52 ; height (m) = 1.732 ± 0.055 ; weight (kg) = 63.5 ± 4.9 ; years of experience (nb) = 14.3 ± 4.3) and High Intensity Interval Training group (HIITG; $n = 10$, age (years) = 15.70 ± 0.5 ; height (m) = 1.7 ± 0.3 ; weight (kg) = 58.9 ± 6.6 ; years of experience (nb) = 14.3 ± 4.3). All participants, were in good health and did not suffer from any disability, musculo-articular, cardiological, neurological or respiratory disease or dysfunction. Before taking part in the study, participants and their parents were informed verbally and written about procedures and possible risks. The study was also approved by the local ethics committee from the Institute of Science and Technology of Physical and Sports Activities, specifically the MLC Laboratory, at Mohamed Boudiaf University of M'sila in Algeria (Date: 15/10/2023; Number: 935). The research was conducted in accordance with the Declaration of Helsinki.

Procedure

A quasi-experimental design with pre- and post-measures was used. The study was a randomized, single-blind, repeated-measures, paral-

lel-group-controlled trial with an equal distribution, divided into two groups, one experimental (HIITG; took part in a training program based on high-intensity interval training) and the other a control group (CG; took part in standard football training).

The design of our training program was based on a previous study [7], that focused on examining the effects of plyometric training or high-intensity interval training on certain physical variables in athletes.

The study was conducted during the winter competitive season of 2023/2024. To minimize the likelihood of potential side effects, two sessions were arranged to acquaint participants with the testing procedures, supplemented by an additional three sessions focused on familiarizing them with the plyometric exercises. These sessions took place immediately before the start of the intervention, directly preceding the baseline assessments (Figure 1). The training program spanned 10 weeks and included sessions dedicated to technical, tactical, as well as combined HIIT and plyometric training, all conducted over the same 10-week period. The testing protocol commenced with a traditional 5-minute run, followed by 10 minutes of body-weight strength and flexibility exercises, a 2-minute dynamic stretching routine, and a 5-minute warm-up specifically tailored for sprints. A break of five to ten min-

Table 1. Anthropometric characteristics of the sample ($n = 20$)

Group	Variable (Mean \pm SD)			
	Age (years)	Height (cm)	Weight (Kg)	Experience years (nb)
HIITG (10)	15.70 ± 0.5	1.70 ± 0.3	58.9 ± 6.6	14.3 ± 4.3
CG (10)	15.6 ± 0.52	1.73 ± 0.055	63.5 ± 4.9	14.3 ± 4.3

(HIITG) High Intensity Interval Training Group; (CG) Control Group; (SD) Standard deviation; (nb) number

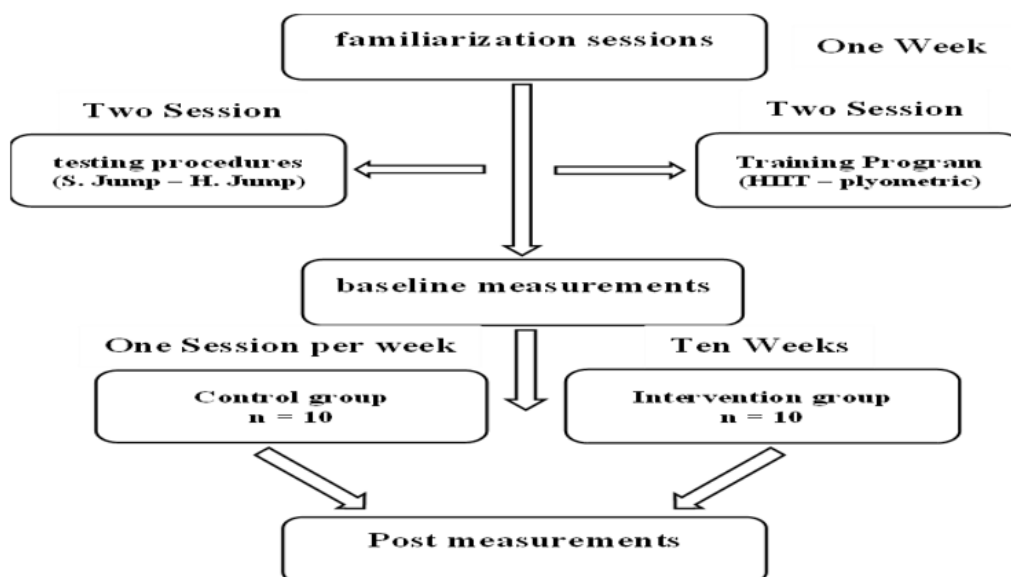


Figure 1. Study design diagram

utes was allowed between each test. Each test consisted of three trials for each participant, with the best results being recorded. Participants wore their normal training attire and soccer boots for the testing, which were conducted outside on a synthetic turf field. The participants underwent in 3–5 soccer sessions weekly, each lasting between 90 and 105 minutes. Combined HIIT and plyometric training occurred once a week in a stadium, lasting for 90 minutes. This included of a 30-minute warm-up, 30–40 minutes of HIIT-style plyometric exercises, and 20–25 minutes of stretching.

Assessment

For measurements of anthropometric variables, we determined the weight and height of the participants. Body weight was measured standing, wearing a T-shirt and shorts, without shoes, to the nearest 0.1 kg, using an electronic scale. Height was measured standing, without shoes, to the nearest 0.5 cm, using a stadiometer (Seca, Hamburg, Germany). For the assessment of the athletes' physical condition, we have followed a protocol of tests, which includes:

Squat Jump test

Participants began the squat jump at a knee angle of 90 degrees without lowering themselves and performed a vertical jump by pushing upward with straight legs (Figure 2). A one-minute rest period was provided between three trials of each test, with the highest jump was selected for further analysis. All vertical jump test were filmed with a phone camera (realme 8 RMX3085_11). Sites of the camera depicting the vertical jump.



Figure 2. How to perform the vertical and horizontal jump test

Phone camera was placed 4m in the sides of the football player. Vertical jump performance was calculated by using the kinovea software (Boston. MA02110-1301USA). Data were collected in the multi-sports stadium, M'sila Province, Algeria by the researchers (MLC Laboratory, M'sila, Algeria).

Horizontal jump test

In the horizontal jump (HJ) test, soccer players initiated the jump from a standing position. They began by bending their knees and swinging their arms to generate maximum forward thrust. Take-off line was marked on the ground, to measure the jump length. The length of the jump was measured using a metric tape measure, from the takeoff line to the nearest point of landing contact, typically the back of the heels.

The combined HIIT and plyometric training program

Both groups underwent standard soccer training sessions lasting 10 weeks. The soccer training regimen comprised exercises focusing on rapid footwork, technical skills encompassing both easy and challenging maneuvers, positional games of varying scale, 1 vs. 1 offensive and defensive drills, and tactical games targeting different objectives. In the experimental group, portion of the regular soccer training was substituted with combined HIIT and plyometric sessions, conducted immediately following regular soccer sessions, (respectively in Table 2 and Table 3).

The plyometric training program outlined in this study aims to improve explosive strength and athletic performance through a carefully structured ten-week regimen of high-intensity exercises. This program features five core plyometric exercises: squat jumps, lateral jumps, vertical jumps, stride jumps, and hurdle jumps. Each exercise is designed to progressively increase in intensity, primarily by augmenting the number of sets and occasionally varying the repetitions to ensure progressive overload.

During the initial weeks, participants will engage in two sets of 6 repetitions for each exercise, emphasizing the importance of mastering proper techniques and establishing a strong foundational ability. As the program progresses, both the number of sets and repetitions will be adjusted to elevate the training load, peaking at a total of 90 repetitions by week five. In weeks six through ten, the training will concentrate on enhancing both volume and intensity, incorporating 8 repetitions across three to four sets per exercise. This allows participants to adapt and further develop their explosive power.

This structured program not only aims to build muscular power and explosive strength but also incorporates different movement patterns to improve coordination, speed, and agility, making it a comprehensive plyometric training regimen,

**Table 2. The high intensity interval-training program for experimental group**

Week	Work	Rest	Sets	Rep	Intensity	%Heart Rate
Week 01	3 × 10s	10s	3	10-15	Low	70-75%
Week 02	3 × 15s	10s	3	10-12	Low	75-80%
Week (03+04)	4 × 10s	10s	4	15	Medium	80-85%
Week (05+06)	4 × 15s	10s	4	12	Medium	85%
Week (07+08)	4 × 20s	10s	4	10	High	90%
Week 09	4 × 25s	10s	4	8	High	95%
Week 10	4 × 30s	10s	4	5-8	High	100%

(HR) Heart rate; Sets x Repetitions

Table 3. The plyometric training program for experimental group

Exercise	Week 01		Week 02		Week 03		Week 04		Week 05	
	Rep	sets	Rep	sets	Rep	sets	Rep	sets	Rep	sets
Squat jump	6	2	6	2	8	2	8	2	6	3
Lateral jump	6	2	6	2	8	2	8	2	6	3
Vertical jump	6	2	6	2	8	2	8	2	6	3
Stride jump	6	2	6	2	8	2	8	2	6	3
Hurdle jumps	6	02	6	2	8	2	8	2	6	3
Total	60		60		80		80		90	
Exercise	Week 06		Week 07		Week 08		Week 09		Week 10	
	Rep	sets	Rep	sets	Rep	Rep	sets	Rep	sets	Rep
Squat jump	6	3	8	3	8	3	6	4	6	4
Lateral jump	6	3	8	3	8	3	6	4	6	4
Vertical jump	6	3	8	3	8	3	6	4	6	4
Stride jump	6	3	8	3	8	3	6	4	6	4
Hurdle jumps	6	3	8	3	8	3	6	4	6	4
Total	90		120		120		120		120	

so it is an effective strategy for athletes aiming to improve their performance in competitive environments.

Statistical Analyses

The data are presented as mean \pm SD. A two-way repeated-measures ANOVA (time \times group) was used to examine the main effects comparing baseline and post-intervention testing, and between the HIITG and CG groups. Independent sample t-tests were used to analyze distinctions between the HIITG and CG groups. Paired sample t-tests were used to analyze within-subject effects for both groups. Additionally, the obtained values underwent further evaluation through the computation of effect size (ES). Effect sizes were utilized to assess whether statistically significant differences held practical importance. These effect sizes were categorized according to the interaction effect between group and time, with results classified as small ($0.00 \leq d \leq 0.49$), medium ($0.50 \leq d \leq 0.79$), and large ($d \geq 0.80$), following Cohen's guidelines. The significance level was set at $\alpha = 0.05$. All statistical analyses were carried out using PASW Statistics version 25.0 (SPSS

Inc., Chicago, IL, USA).

We determined the reliability of measurements from SJ and HJ tests through ICC calculations (52), finding that all measures achieved satisfactory reliability levels (SJ: $r = 0.779$; HJ: $r = 0.80$). Our criterion for statistical significance was $p < 0.05$, irrespective of whether a positive or negative difference was observed.

Results

The analytical system used in this study includes three steps, including the use of both the Shapiro-Wilk test, the paired sample t-test and ANOVA test. As shown in Table 4, the normal distribution of the data was confirmed by the Shapiro-Wilk test based on the pre- and post-test results of the control and experimental groups.

According to the data presented in Table 5 and the findings of the Paired Sample t-Test, the SJ and HJ tests of explosive power in the experimental group exhibited a statistically significant enhancement in explosive power, as indicated by the obtained significance values for both the SJ and HJ tests (SJ = $0.012 < 0.05$, HJ = $0.004 <$

**Table 4. Normality test calculation on the effect of combining HIIT with plyometric exercises on explosive power among young football players**

	Variables	Groups	Shapiro-Wilk	
			Statistic	Significant
Pre-tests	SJ	HIITG	0,884	0,146
		CG	0,821	0,126
	HJ	HIITG	0,926	0,411
		CG	0,977	0,944
Post-tests	SJ	HIITG	0,960	0,781
		CG	0,878	0,125
	HJ	HIITG	0,948	0,641
		CG	0,979	0,958

(HIITG) High Intensity Interval Training Group; (CG) Control Group; (SJ) Squat Jump; (HJ) Horizontal Jump.

Table 5. Conduct a paired-sample t-test analysing the pre- and post-jump vertical and horizontal performance levels of both participating groups

Groups	Variables	Test	Statistic	Paired-sample t-test	
			Mean \pm SD	t	Sig
HIITG	SJ	Pre	0.468 \pm 0.1621	-3,163	0,012
		Post	0.517 \pm 0.120		
	HJ	Pre	2.224 \pm 0.0359	-3,847	0,004
		Post	2.318 \pm 0.0316		
CG	SJ	Pre	0.322 \pm 0.113	-1,198	0,261
		Post	0.310 \pm 0.111		
	HJ	Pre	1.945 \pm 0.0982	0,678	0,515
		Post	1.935 \pm 0.0107		

(HIITG) High Intensity Interval Training Group; (CG) Control Group; (SJ) Squat Jump; (HJ) Horizontal Jump; (t) T-calculated; (sig) signification

Table 6. Comparative measurements on vertical and horizontal jumps before and after the 10-week study period involving the experimental and control groups

Performance Tests	HIIT Group (Mean \pm SD)		Control Group (Mean \pm SD)		ANOVA Group x Time interaction
	Pre	Post	Pre	Post	P-Value
SJ test (m)	0.468 \pm 0.1621	0.517 \pm 0.120	0.322 \pm 0.113	0.310 \pm 0.111	0.003
HJ test (m)	2.224 \pm 0.0359	2.318 \pm 0.0316	1.945 \pm 0.0982	1.935 \pm 0.0107	0.001
Height (m)	0.130 \pm 0.107	0.327 \pm 0.097	0.2380 \pm 0.106	0.248 \pm 0.096	0.016

(HIITG) High Intensity Interval Training Group; (CG) Control Group; (SJ) Squat Jump; (HJ) Horizontal Jump; (SD) Standard deviation; (P) significant value

0.05) after undergoing a ten-week combined HIIT and plyometric training program. Conversely, the control group did not exhibit significant enhancements in explosive power tests (SJ and HJ), as indicated by two-tailed significance values of SJ = 0.261 and HJ = 0.515, both surpassing the 0.05 threshold.

Based on the results of Table 6, the baseline and post-intervention values for all variables. Initially, there were no significant differences in performance measures between the control and experimental groups. However, both groups exhibited enhanced athletic performance through-

out the 10-week trial, indicating a significant time effect. Moreover, there was a significant group effect, with the experimental group showing noteworthy enhancements in vertical jump compared to the control group across all tests ($p = 0.003$; SJ: $p < 0.05$). The intervention group also showed a substantial improvement ($p < 0.05$) in the horizontal jump ($p < 0.001$). However, Distance/Height of jump increase over the intervention (D/H: $p < 0.05$). The experimental group exhibited performance enhancements across all tests. All significant effects were classified as important, suggesting greater improvements in performance

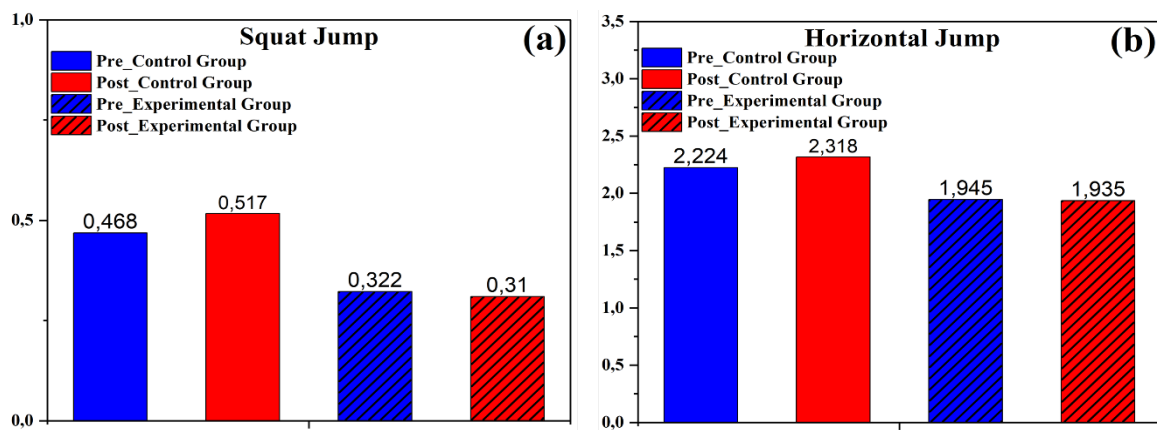


Figure 3. Compared the performance changes in (A) SJ, (B) HJ between groups; CG = control group; HIITG = High intensity interval training group.

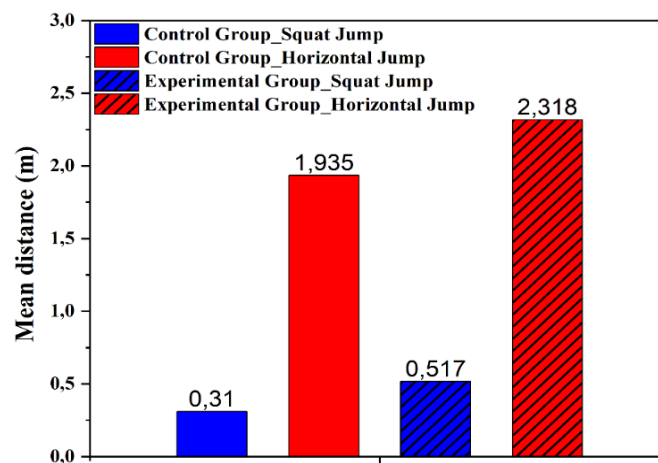


Figure 4. Mean post-test results of explosive power performance for control versus intervention groups

in the experimental group compared to the control group.

In the present intervention, the improvement in vertical and horizontal jump performance was greater than that reported in other studies published in the literature [7], as shown in figures 2 and 3. The percentage increases in vertical and horizontal jumps after the intervention training program were considered significant.

Discussion

One of the aims of this research was to determine whether the combined HIIT and plyometric training program would improve some physical performance of junior soccer players. The results suggest a significant boost in the intervention group's jumping prowess following ten weeks of combined HIIT and plyometric training. This aligns with the outcomes of previous research conducted by Rimmer and Sleivert [16], although the timeframe of their study remains unspecified. Scholarly sources have elaborated that engaging in explosive exercises has the capacity to enhance power [16, 17]. Other investigations have simi-

larly demonstrated that engaging in plyometric training on a rigid surface can affect an individual's jumping capabilities [18]. In plyometric training, the efficacy of jumping performance is associated with the utilization of stretch-shortening cycles. Moreover, short training sessions play a supportive role in maximizing the potential benefits of HIIT [19]. Indeed, it is worth exploring the potential benefits of exercise modes that activate a higher proportion of muscle fibers, including Type II motor units, may yield distinct and potentially more beneficial effects warrants further examination [20].

The outcomes of this study emphasize the significance of incorporating HIIT with PL to enhance jump efficiency in U17 football players. The compared between the intervention and control group show that the participants in the experimental group displaying the most notable improvements in jump efficiency, while those in the control group demonstrated the lowest jump performance. This highlights the importance of HIIT in improving athletic performance. Notably, HIIT workouts with rigorous protocols like these impose physiological demands akin to those experienced during an



authentic soccer match. During such sessions, heart rates typically maintain an average of 85% of maximum heart rate (HRmax), with intensities peaking as high as 90–95% of HRmax [21, 22]. This suggests that excelling in any vertical jump is correlated with maximal strength, speed, and explosive power [23]. A recent study indicates that implementing a diverse plyometric frequency-training schedule has proven highly effective in boosting leg power [2]. Muscles play a vital role in the execution of this training program, as relying solely on body weight may not provide adequate resistance for standing long jumps. Furthermore, muscular strength and power significantly impact jump performance. Reconsidering the notion of “overload” is pivotal in effectively strengthening muscles [24]. When considering the effects of individual exercises, combining these elements is likely to yield greater gains. Moreover, incorporating a variety of plyometric activities, such as squat jumps, lateral jumps, vertical jumps, stride jumps, and hurdle jumps, with HIIT regimen tends to produce superior training outcomes compared to performing only one type of exercise. Consistently adhering to training regimes can contribute to further improvements in jump performance. Engaging in more vertical and horizontal jumping exercises can also enhance jump performance. The capability to execute complete jumps is regarded as a crucial aspect during football matches. Hence, a key element for ongoing progress appears to be the enhancement of maximum strength, which is often indispensable for achieving success. Further refinement of these abilities appears beneficial for young soccer players, as indicated by the outcomes of HIIT [25]. This boosts their leaping prowess through refining neuromuscular adjustments (like intra- and intermuscular coordination) and facilitating swift movements (founded on a brief stretch cycle). The enhancement in drive control, stretch-shortening capacity, or musculoskeletal resilience resulting from enhanced leg explosive strength is likely attributable to enhancements in drive control, stretch-shortening capacity, or musculoskeletal strength and resilience [1].

HIIT shows positive effects on the performance of ice hockey players, indicating that this training method can lead to significant enhancements in athletes' power output [26]. Some previous research has investigated the effect of HIIT training on jump performance. Indeed, a study by Nobuaki Tottori et al show After participating in a 7-week HIIT program twice a week, children with an average age of 9.7 ± 0.8 years, demonstrated a significant enhancement in their standing long jump by 9.6% ($p < 0.001$) [27]. Furthermore, Linback (2014) demonstrated that engaging in HIIT exercise enhances the explosive power

of the lower extremities, resulting in an elevated vertical jump, thereby improving the body's ability to generate explosive force and ascend higher [23]. The results outperform those observed in earlier studies. Nevertheless, comparisons are challenging due to the absence of information regarding the participants' training status in another research.

As per an earlier study, plyometric exercise was found to boost essential elements of athletic performance in young runners when compared to conventional in-season training [28]. Moreover, it has been shown that HIIT workout is able to increase significantly the power, and performance in team sport [29]. After a sixteen-week plyometric training program (including Multiple 5 Bounds and Standing Long Jump Test), athletes' power can be boo [4]. Prior studies have recommended maintaining a plyometric training routine to enhance the explosive actions of athletes [30]. In sports that entail jumping movements, plyometric training is indispensable as it is seen as a highly effective method for enhancing jump performance [4], Training enhancements are evident irrespective of fitness level when plyometric training is executed correctly. In another study employing the same test (SJ-testing), the advantages of a short plyometric training program were demonstrated for male high school adolescents (aged 16.89 ± 0.85 years), underscoring the importance of plyometric training in enhancing explosive strength efficiency. Plyometric activities are commonly utilized to enhance explosive power [31]. The benefit of plyometric training is that it's very effective and requires less time, space, and equipment to perform training sessions. Nevertheless, despite its effectiveness, the optimal design for plyometric training, including frequency, volume, and height of descent, to effectively support muscle strength development has not been established with certainty by a number of prior research investigations [32].

Another interesting discovery was that the ideal stimulus for generating noticeable neuromuscular changes in athletes could be a fairly hard training surface and a smaller number of plyometric exercises. Therefore, the combination of particular exercise [33], and high repetition count may be an important factor in enhancing sprint performance, maybe through the promotion of motor learning adaptations [34]. To sum up, there was a substantial improvement in the explosive power performance of U17 soccer players after a 10-week mixed HIIT and plyometric training regimen, which solely consisted of jumping activities. While both a solid training surface and a substantial plyometric training volume impacted jump performance, it was only the integration of high-volume training on a hard surface

that resulted in heightened jumping activity post-session. This suggests that this particular combination was particularly effective in fostering performance improvements. Conversely, increased volume or a firmer training surface might constrain the improvements in maximal jump height or pure concentric strength (e.g., squat jumps) when rapid stretch-shortening cycle (SSC) muscle actions are employed during training.

Conclusion

The outcomes of this research reveal that the explosive force performance of U17 soccer players saw enhancement after undergoing a 10-week program that integrated both high-intensity interval training (HIIT) and plyometric exercises. The training system was applied consistently on a weekly basis at the same time for all athletes, and they had uniform academic schedules. This approach successfully mitigated any potential biases resulting from differences in training timing or procedures. This study demonstrates how a carefully designed exercise regimen, rooted in scientific principles, can significantly enhance expected physical traits. Maintaining an effective exercise program success necessitates a serious approach to exercise management and implementation. Through precise monitoring of diverse volumes and intensities of HIIT training alongside plyometric exercises to identify the optimal dosage for development, this training regimen could be recommended as an effective training strategy to facilitate adaptations conducive to enhancing explosive power performance in male soccer players. Because of these findings, coaches will have the opportunity to more effectively introduce training regimens and boost players' explosive power levels ahead of the football season.

The study revealed that integrating high-intensity interval training with plyometrics exercises advantages for enhancing lower body explosive strength performance. Given that many sports place a significant emphasis on explosive fitness components, the combination of HIIT and plyometric training can enhance these attributes, providing benefits for coaches, researchers in physical education and sports sciences practices. Building upon these findings, we propose the adoption of high-intensity intermittent training coupled with plyometric exercises as an effective training method to elevate the level of explosive strength among football players under 17 years of age.

This proposed training protocol serves as an important component of neuromuscular training sessions, focusing on developing lower body explosive power and thus preventing lower extremity injuries. When under professional supervision and crafted with precision, the program ensures minimal strain on the athlete's musculoskeletal

system, thereby decreasing the likelihood of injuries.

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Supplementary Information

Article details

The online version available at

<https://doi.org/10.15391/snsv.2025-1.01>

Acknowledgement

The author Laidi Abderrahim would like to express his gratitude to the researchers; HM and MSH who helped to realize all parts of this research.

Conflict of interest

All authors confirm that there is no conflict of interest in this study.

Application for funding

The current study received no specific funding. Its implementation took place at the expense of attracting the authors' own funds.

Received: October 28, 2024; Accepted: February 6, 2025

Published: March 30, 2025

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