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ORIGINAL ARTICLE

The effect of 8 weeks of plyometric jump training on repeated sprint ability and aerobic capacity in young soccer players

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ABSTRACT

This study aimed to investigate the impact of 8 weeks of in-season plyometric jump training on the repeated sprinting capacity (RSA) and aerobic capacity of young male soccer players. A total of 24 participants were assigned to the plyometric training group (PG; n = 13; age 16.61 ± 0.50 years, body mass 54.30 ± 6.12 kg, height 1.72 ± 0.30 m; biweekly plyometric training in addition to regular soccer training) or the control group (CG; n = 11; age 16.18 ± 0.40 years, body mass 53.09 ± 4.39 kg, height 1.69 ± 0.06 m; regular soccer training only). The players were tested for RSA using a protocol consisting of 6 × 35 m sprints, with 10 seconds of passive recovery between sprints. Aerobic capacity was determined using the Yo-Yo Intermittent Recovery Test Level 1. The results showed that the PG group had significant improvements in RSA_{best} (p < .01), RSA_{mean} (p < .01), and VO_{2max} (p < .002) compared to the CG group. In contrast, the control group showed a decline in VO_{2max} and a worsening of RSA_{mean} times. The findings suggest that biweekly plyometric training for 8 weeks can enhance RSA performance and aerobic capacity in young soccer players. Coaches should progress training volume and intensity gradually while ensuring appropriate jumping technique and body position during the jump phase to improve effectiveness and reduce injury risk.
Keywords: sport medicine; plyometric jump training; repeated sprint ability; aerobic capacity; soccer players.

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INTRODUCTION

Soccer is a sport that is widely recognized for its intermittent nature. Players' performance is influenced by a variety of physiological, technical, and tactical factors. Coaches and sports scientists strive to enhance players' fitness during soccer matches through various activities, including dynamic movements such as jumping, shooting, passing, and dribbling. These activities also involve running at different distances and intensities. According to time-motion analysis, fast running accounts for 1-10% of the total distance covered (Spencer et al., 2004). To meet game demands, players engage in 150 to 250 short, high-intensity activities, such as possession and defensive intervention drills (Mohr, Krustrup, & Bangsbo, 2003).

Players' speed and ability to recover between high-intensity exercises, in addition to repeated sprint ability (RSA), are among the most important factors that determine players' efficiency. An athlete's ability to maintain maximum speed throughout subsequent sprints is known as repeated sprint ability (RSA). This ability is performed and measured with short sprints with a minimum of 30-second rest periods between repetitions (Turner & Stewart, 2013). RSA is a complex trait, likely affected by neuromuscular and metabolic factors, including oxidative capacity for phosphocreatine (PC) recovery (Glaister, 2005; Spencer, Bishop, Dawson, & Goodman, 2005).

Fast movements and powerful jumping or multi-joint jumping are among the most important exercises involved in plyometric training (Bouguezzi et al., 2020). In addition to vertical and horizontal jumping, Plyometric Jump Training (PJT) has received considerable attention from researchers, especially in sports such as football and basketball. Research has consistently shown that this type of training is effective in enhancing performance, particularly in sprinting and strength-related abilities (Markovic & Mikulic, 2010).

PJT involves a stretch-shortening cycle (SSC), which consists of a lengthening (eccentric) movement quickly followed by a shortening (concentric) movement (Ebben, Simenz, & Jensen, 2008). Furthermore, it includes exercises that place stress on the musculotendinous unit (Taube, Leukel, & Gollhofer, 2012). PJT has been shown to improve neuromuscular coordination by increasing the efficiency of the nervous system (Silva et al., 2019). In a study by Ramírez-Campillo et al. (2018), PJT demonstrated positive effects on neuromuscular function, metabolism, cardiovascular health, and body composition.

Research shows that plyometric training can effectively enhance a variety of physical abilities, including strength and sprinting performance, in both males and females (Stojanović, Ristić, McMaster, & Milanović, 2017). Furthermore, it can be highly effective when performed with the appropriate training volume and frequency (de Villarreal, Kellis, Kraemer, & Izquierdo, 2009). PJT is often programmed over a period of 6 to 12 weeks, with a recommended frequency of 1 to 3 sessions per week. It is important to note that PJT exercises should be performed at maximal or near-maximal intensity to achieve optimal results (Sánchez et al., 2020), which can be controlled by the number of jumps performed during each session (Bouguezzi et al., 2020).

However, there is a lack of studies examining the effects of PJT on repeated sprint ability (RSA). Some studies, such as that of Negra et al. (2020), found that 8 weeks of training including plyometric exercises improved both RSA_{best} and RSA_{total} in young soccer players. The PJT program in this study enhanced explosive performance, which may contribute to improved change-of-direction (CoD) ability during RSA testing. In contrast, Hermassi et al. (2014) found no significant differences between groups in repeated sprint ability performance (p = .062). These conflicting findings highlight the need for further research on the impact of plyometric training on RSA.

Therefore, the primary aim of this study was to investigate the effects of an 8-week PJT program on RSA performance. A secondary aim was to examine its effect on players' aerobic capacity.

METHODS

Experimental approach to the problem

To evaluate the impact of 8 weeks of Plyometric Jump Training (PJT) on the repeated-sprint ability (RSA) of young soccer players, a two-group experimental design was utilized. Twenty-four players were randomly assigned to either the experimental group (n = 13) or the control group (n = 11). Prior to the physical tests, familiarization sessions were conducted to explain the procedures to the participants. The weekly training program consisted of a total of 5 sessions, including 2 standard training sessions. The RSA test was performed at least 48 hours after the last training session or competition, under the same experimental conditions. All participants were instructed to wear appropriate sports shoes for artificial playing fields before the test, which was conducted at 5 PM.

Participants

Twenty-four young football players from the same team voluntarily participated in this study. They were divided into two groups: the experimental group (n = 13; age 16.61 ± 0.50 years, height 1.72 ± 0.30 m, body mass 54.30 ± 6.12 kg) and the control group (n = 11; age 16.18 ± 0.40 years, height 1.69 ± 0.06 m, body mass 53.09 ± 4.39 kg). Detailed data for both groups can be found in Table 1. Each player had four years of training experience and followed a training schedule of five sessions per week, with each session lasting an average of 90 minutes. The team also competed in the local regional league and cup championship. Participants were informed of the nature of the study, and written consent was obtained from their parents or legal guardians. The study protocol was approved by the University Ethics Committee and Scientific Council.

Table 1. Age and anthropometric data of the included subjects.

	PJT_G (n = 13)	**CON_G (n = 11)**
Age (y)	16.61 ± 0.50	16.18 ± 0.40
Height (m)	1.72 ± 0.30	1.69 ± 0.06
Body mass (kg)	54.30 ± 6.12	53.09 ± 4.39

Note. PJT_G = plyometric jump training group; CON_G = control group.

Procedure

The schedule for conducting physical tests was established as part of the team's weekly training plan. The first day consisted of taking morphological measurements, the second day involved the YIRT1 test, and the third day included the RSA test. The physical tests were separated across specific days to ensure complete recovery and prevent fatigue from affecting performance. All participants were familiar with the correct execution of the tests. A standardized warm-up protocol was used before testing, consisting of light running, general and specific warm-up movements, dynamic stretching, and short horizontal jumps. This warm-up routine was designed to prepare the participants physically and physiologically for the tests, ensuring optimal performance and reducing injury risk. The warm-up typically lasted between 15 and 20 minutes.

The Yo-Yo intermittent recovery test

The Yo-Yo Intermittent Recovery Test is a scientifically reliable method for measuring an athlete's ability to perform repetitive intense exercise and activate their aerobic system. The test is conducted over a distance of 20 meters, with the athlete running back and forth while being controlled by audio alerts from the test device. A 10-second recovery time is given between each run. The test consists of four rounds at a speed of

10–13 km·h−1, followed by seven rounds at a speed of 13.5–14 km·h−1. The speed then increases in increments of 0.5 km·h−1 after every eight bouts of running. If a player fails to continue or does not follow an audible warning, they are eliminated from the test. Only one warning is given to players.

Anthropometric measurements
Height and body mass were measured before the start of the experiment in both groups using a wall-mounted stadiometer (seca 264) for height and an electronic scale for body mass.

RSA test
The test consisted of six repetitions of running at maximum speed for a distance of 35 meters, with a 10-second recovery period between each repetition. Participants were instructed to perform this test immediately after a 10-minute warm-up and were advised not to do any practice runs as they were already familiar with the test protocol. Prior to starting the sprint, participants were asked to stand with their feet shoulder-width apart and their arms by their sides for five seconds. The best sprint time (RSA_{best}) and the mean sprint time across repetitions (RSA_{mean}) were recorded. The validity and reliability of this test have been verified by Zagatto, Beck, and Gobatto (2009).

Fatigue index
The fatigue index is an important physiological indicator related to sprint repetition and athletes' recovery ability between sprint repetitions. In this study, FI was calculated using the following equation: FI (%) = [(worst time − best time) / best time] × 100. The resulting values were interpreted according to the following thresholds: <5% excellent, 5.1% to 9.0% good, 9.1% to 13.0% average, and >13% poor.

Training interventions
Both the PJTG and CONG groups participated in a regular football training program for 8 weeks, consisting of five training sessions per week. In addition, the PJTG group performed plyometric jump training during two of these weekly sessions. The duration of each training session ranged from 75 to 90 minutes, depending on weather conditions and specific training objectives. Neither group participated in any strength training program throughout the intervention period.

Each training session began with a 15-minute warm-up that incorporated the plyometric jumps required for that session. The plyometric training sessions lasted approximately 25 to 30 minutes and included vertical, horizontal, and lateral jumps performed over hurdles of varying heights, followed by sprint exercises.

Table 2. Plyometric jump training program.

Week	Volume sets × (reps)	Ground contacts	
		Session 1	Session 2
1	4–5 sets (12 reps)	48	60
2	4–5 sets (12 reps)	48	60
3	4–5 sets (16 reps)	64	80
4	4–5 sets (16 reps)	64	80
5	4–5 sets (20 reps)	80	100
6	4–5 sets (20 reps)	80	100
7–8	5 sets (24 reps)	120	120

Note. Reps = repetitions.

For each exercise, the number of repetitions, rest intervals, and total ground contacts were predefined and are presented in Table 2. Work-to-rest ratios ranged from 1:5 to 1:10, while rest periods between sets lasted between 3 and 3.5 minutes. These recovery intervals were established according to the intensity and volume of training, the content of each training session, and the athletes' adaptation to the imposed training loads.

Participants were instructed to perform all exercises with maximal effort while maintaining proper technique during ground contact. In addition, verbal feedback and encouragement were provided throughout the sessions to ensure optimal execution and performance.

Statistical analysis

Data are shown as mean ± standard deviation (SD). Normality of distribution and equality of variance were confirmed using the Shapiro-Wilk and Levene tests, respectively. A two-way mixed analysis of variance (two-way mixed ANOVA) was conducted to examine the main effects of the between-subjects factor (group: experimental vs. control), the within-subjects factor (time: pre-test vs. post-test), and their interaction (group × time). Statistical significance was set at $p < .05$. Partial eta squared (ηp^2) was used to assess effect size, with values classified as small (.01), medium (.06), and large (.14). All statistical analyses were conducted using SPSS version 27.

RESULTS

A two-way mixed ANOVA revealed highly significant Group × Time interaction effects for VO_{2max} ($F(1, 22) = 38.14$, $p < .001$, $\eta p^2 = .634$), RSA_{mean} ($F(1, 22) = 16.25$, $p < .001$, $\eta p^2 = .425$), and RSA_{best} ($F(1, 22) = 7.48$, $p = .012$, $\eta p^2 = .254$), demonstrating that training adaptations over time differed significantly between groups. Simple effects analyses confirmed that the experimental group achieved substantial performance enhancements, evidenced by a marked increase in VO_{2max} (from 52.24 ± 5.77 to 59.97 ± 7.65) and a notable reduction in RSA_{best} sprint times (from 5.36 ± 0.45 to 4.77 ± 0.40 s). Conversely, the control group showed a slight decline in VO_{2max} and a significant worsening of RSA_{mean} times (from 5.54 ± 0.39 to 6.02 ± 0.55 s). Finally, for the Fatigue Index (FI%), no significant interaction was observed ($F(1, 22) = 0.001$, $p = .967$); however, a highly significant main effect of time ($F(1, 22) = 26.92$, $p < .001$, $\eta p^2 = .550$) indicated a uniform increase in fatigue values from pre- to post-test across both groups.

DISCUSSION

The main objective of this study was to investigate the effect of a plyometric jump training program on repeated sprint ability (RSA) and aerobic capacity in young soccer players. The results showed significant improvements in RSA_{best}, RSA_{mean}, and VO_{2max} after 8 weeks of training that included plyometric jump exercises. In contrast, the control group showed a decline in VO_{2max} and a worsening of RSA_{mean} times, with no comparable training-related improvements.

The findings of the present study are consistent with those reported by Negra et al. (2020), who found that 8 weeks of plyometric training combined with regular soccer training produced greater improvements in fitness measures such as repeated sprint ability, 20-m sprint performance, jumping ability, and change-of-direction performance in prepubertal male soccer players. Similarly, Hermassi et al. (2014) observed significant improvements in RSA performance, including best, mean, and total sprint times, after incorporating plyometric exercises into traditional handball training programs. However, no significant changes were found in the RSA fatigue index (RSA_{FI}).

Table 3. Two-Way mixed ANOVA statistical parameters and descriptive profiles across performance variables.

Dependent variable	Descriptive Statistics (M ± SD)		Source of variation	SS	df	MS	F	*p*-value	Effect Size (ηp²)
	Pre-Test	Post-Test							
VO_2max (mL·kg⁻¹·min⁻¹)	53.93 ± 2.88 52.24 ± 5.77	52.80 ± 3.70 59.97 ± 7.65	Group (Between)	59.20	1	59.20	1.66	.211	.070 (Medium)
			Time (Within)	280.05	1	280.05	26.34	< .001***	.545 (Large)
			Group × Time	405.51	1	405.51	38.14	< .001***	.634 (Large)
			Error (Within)	234.14	22	10.64	—	—	—
RSAmean (s)	5.54 ± 0.39 5.45 ± 0.49	6.02 ± 0.55 5.36 ± 0.45	Group (Between)	1.54	1	1.54	4.34	.049*	.165 (Large)
			Time (Within)	0.44	1	0.44	5.91	.024*	.212 (Large)
			Group × Time	1.20	1	1.20	16.25	< .001***	.425 (Large)
			Error (Within)	1.62	22	0.07	—	—	—
RSAbest (s)	5.21 ± 0.38 5.36 ± 0.45	5.33 ± 0.57 4.77 ± 0.40	Group (Between)	0.94	1	0.94	3.50	.075	.137 (Medium)
			Time (Within)	0.31	1	0.31	3.05	.095	.122 (Medium)
			Group × Time	0.77	1	0.77	7.48	.012*	.254 (Large)
			Error (Within)	2.27	22	0.10	—	—	—
Fatigue Index (FI %)	6.30 ± 2.23 5.40 ± 3.43	13.35 ± 7.42 12.43 ± 3.44	Group (Between)	9.06	1	9.06	0.59	.449	.026 (Small)
			Time (Within)	507.03	1	507.03	26.92	< .001***	.550 (Large)
			Group × Time	0.02	1	0.02	0.001	.967	.000 (Null)
			Error (Within)	414.37	22	18.84	—	—	—

*Note. N = number of participants; Mean = arithmetic mean; SD = standard deviation; df = degrees of freedom; F = variance ratio; ηp² = partial eta squared. *p < .05, ***p < .001.*

In contrast, Mazurek et al. (2018) reported that a standard five-week training program consisting of only 15 plyometric sessions was insufficient to achieve significant improvements in jumping performance, repeated sprint ability, and aerobic capacity among young male handball players. These findings suggest that training duration may play a critical role in the effectiveness of plyometric interventions.

Previous research has proposed that improvements in sprinting and RSA performance following Plyometric Jump Training (PJT) are mainly explained by mechanical adaptations. These include reduced ground contact time, increased tendon and muscle stiffness, enhanced utilization of the elastic properties of the musculotendinous system, and improved movement economy (Markovic & Mikulic, 2010). Additionally, increased motor unit recruitment may contribute to enhanced sprint performance.

Although the duration of our training intervention was similar to that used in previous studies, differences existed in training volume and intensity. In the present study, participants performed approximately 130-150 jumps per session. By comparison, Mazurek et al. (2018) implemented 180-250 jumps per session, whereas Negra et al. (2020) reported 60-120 foot contacts per session. Variations in training volume may be related to differences in performance level, biological maturity, and training age of participants.

However, the improvement in repeated sprint ability observed in our study may not be solely explained by these factors. Other physiological and mechanical variables that were not measured may also influence sprint performance. Future research should therefore include additional assessments to better understand the mechanisms underlying improvements in RSA.

Interestingly, no significant improvements were observed in the Repeated Sprint Ability Fatigue Index (RSA_{FI}), which is consistent with several previous studies. The fatigue index is considered an important indicator of an athlete's capacity to sustain performance during repeated sprinting. It has traditionally been assessed through the percentage decline in sprint performance across repetitions or by changes in countermovement jump (CMJ) performance before and after RSA testing (Morcillo et al., 2015).

Consequently, CMJ performance has been suggested as a useful marker of neuromuscular fatigue. Previous evidence has shown that performance deterioration may occur after only a single 6-second sprint, indicating a reduction in force-production capacity. Furthermore, recovery periods of 30 seconds may be insufficient to fully restore the force-generating capacity required for subsequent efforts (Mendez-Villanueva et al., 2008).

These findings reinforce the physiological relationship between RSA and oxidative capacity, particularly the restoration of phosphocreatine (PCr) and the buffering of hydrogen ions (H^+), both of which are essential for maintaining performance during repeated maximal efforts (Buchheit et al., 2010). A deeper understanding of fatigue mechanisms during repeated sprinting may provide valuable insights into the development of RSA.

Regarding aerobic capacity, the experimental group demonstrated significant improvements compared with the control group, which showed no meaningful changes. These findings agree with those reported by van de Hoef et al. (2020), who observed improvements in aerobic fitness following PJT in soccer players. Such improvements may be explained by enhanced neuromuscular efficiency, which reduces the energy cost of running.

Similarly, Los Arcos et al. (2014) reported improvements in endurance following plyometric training programs involving both vertical and horizontal jump exercises, with no significant differences between training modalities. Nevertheless, other studies have failed to demonstrate improvements in aerobic capacity following plyometric interventions.

For example, Mazurek et al. (2018) concluded that five weeks of training were insufficient to provide an additional physiological stimulus capable of improving cardiovascular variables. Differences between studies may be attributable to variations in training methodology, participant characteristics, competitive level, or the interaction between traditional soccer training and PJT.

It is also possible that highly trained athletes experience slower rates of adaptation compared with less-trained individuals, making it more difficult to observe significant gains in physical performance. In such cases, the training stimulus may be insufficient to elicit further improvements.

Numerous studies have also explored the relationship between repeated sprint ability and aerobic capacity (Rodríguez-Fernández et al., 2019). Some authors have suggested that aerobic fitness contributes to the restoration of phosphocreatine stores and accelerates recovery between maximal efforts, thereby enhancing RSA performance and VO_{2max} (Bogdanis et al., 1996).

However, other studies have reported no significant association between aerobic capacity and repeated sprint performance. Aziz et al. (2007) found no correlation between measured VO_{2max} and RSA performance, while Dardouri et al. (2014) reported no significant relationship between repeated sprint indices, estimated VO_{2max}, or vertical jump performance.

These discrepancies may be explained by differences in RSA testing protocols, including sprint distance (20-30 m vs. 40 m), exercise modality (running vs. cycling), and participant characteristics such as age and training level. Sanders et al. (2017) suggested that shorter sprint distances may be more appropriate for evaluating the relationship between RSA and aerobic fitness in soccer players because longer protocols increase the contribution of aerobic metabolism.

Therefore, RSA protocols such as those used in the present study may not exhibit strong correlations with VO_{2max} because of their relatively short effort durations (Rodríguez-Fernández et al., 2019).
Finally, one limitation of the present study is that the relationship between aerobic capacity and RSA was not directly investigated. Additionally, vertical and horizontal jump tests were not included. These assessments could provide valuable information for better understanding the mechanisms underlying the observed performance improvements and should be considered in future research.

CONCLUSION

The results of this study revealed positive improvements in repeated sprint ability and aerobic capacity in young soccer players after 8 weeks of plyometric jump training in addition to standard soccer training. These improvements may be attributed to the effectiveness of the training program, as the number of training weeks, scheduled sessions, volume, and intensity were consistent with most related studies. Nevertheless, the number of jumps and the training surface may influence the effectiveness of plyometric jump training.

AUTHOR CONTRIBUTIONS

All authors meet the criteria for authorship in accordance with established ethical guidelines. Contributions are specified according to the CRediT (Contributor Roles Taxonomy) as follows: Conceptualisation: Aissa

Chouaf. Methodology: Abdelkader Khelif. Formal analysis: Aissa Chouaf. Investigation: Aissa Chouaf. Data curation: Aissa Chouaf, Abdelkader Khelif. Writing – original draft: Aissa Chouaf. Writing – review & editing: Abdelkader Khelif. Supervision: Abdelkader Khelif.

All authors have critically reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

AI USE DISCLOSURE

In accordance with current publishing ethics and transparency recommendations, artificial intelligence (AI) tools were used solely to assist with translation and language editing, with the aim of improving clarity and readability. No AI tools were used in the generation of scientific content, including the study design, data collection, analysis, interpretation of results, or the formulation of conclusions. The authors retain full responsibility for the content of the manuscript and confirm its originality, integrity, and accuracy.

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