The journal « The challenge »:ISSN 9859-1112EISSN2602-6619:
Volume: 15 Issue: 02/ 2023, Pages 553 - 568

The effect of combined plyometric training and sprint with change of direction on repeated change of direction and repeated sprint ability in U19soccer players

Yazid Derraa*[1], Ridha Malek[2]
[1] Institute of Science and Technology ofPhysicaland Sports Activities- OumEl-Bouaghi University (Algeria),derraa.yazid@univ-oeb.dz
[2] Institute of Science and Technology ofPhysicaland Sports Activities- OumEl-Bouaghi University (Algeria),malek1972@gmail.com
*laboratoryofbiologicalandpsychologicalresponsestophysicalactivity- OumEl-Bouaghi University (Algeria)

Received: 15/02/2023 Accepted: 13/06/2023 Published: 24 /07/2023

Abstract:

The aim of the current study was to investigate the effect of short-term combined plyometric training and sprinting with change of direction on repeated change of direction and repeated sprint ability in soccer players under 19 years old. Twenty soccer players participated in this study. The subjects were randomly assigned to the experimental group (EG; n = 10, age: 17.6 ± 0.52 years) and control group (CG; n = 10, age: 17.5 ± 0.53 years). Pre- and post-intervention measures were repeated change of direction and repeated sprint ability tests. Data were analyzed using paired sample t-tests and independent sample t-tests (IBM SSPS 29.0). The statistical analysis revealed significant improvement within the experimental group in three RCOD measures: RCOD-TT (*p* =.002, *d* = 1.36); RCOD-FT (*p* =.006, *d* = 1.12); and RCOD-AT (*p* =.002, *d* = 1.36). Furthermore, RSA variable measures showed meaningful improvements with moderate effect size in RSA-TT (*p* =.013, *d* = 0.97), RSA-FT (*p* =.013, *d* = 0.97), and RSA-AT (*p* =.014, *d* = 0.96). Between-group analyses showed moderate performance improvements in the RCOD-TT (*p* =.022, *d* = 1.12), RCOD-AT (*p* =.022, *d* = 1.12), RSA-TT (*p* =.036, *d* = 1.01), and RSA-AT (*p* =.038, *d* = 1) in the experimental group more than in the control group. However, there was no significant difference in all RCOD and RSA measures within the control group. According to these results, short-term combined plyometric and change of direction training would be sufficient to enhance RCOD and RSA parameters (total time, fastest time, and average time), but not percentage decrement (fatigue index) and the RSA/RCOD index among U-19 soccer players.

Keywords: combined training: plyometric: sprint: change of direction: repeated change of direction: repeated sprint ability: soccer.

Corresponding author: DERRAA Yazid E-mail: derraa.yazid@univ-oeb.dz

Introduction

Soccer is a multidirectional, intermittent sport due to the performance of high-intensity, short-duration movements in multiple directions and turns with a short rest period during the match(Dolci et al., 2020).

The ability to perform high-intensity efforts that involve frequent changes of direction (COD) and sprints is a key determinant of physical performance and match outcome in soccer for the purposes of feinting, tackles, creating space, receiving the ball in a good position, and scoring goals (Bloomfield et al., 2007; Dellal et al., 2011; Di Salvo et al., 2010; Faude et al., 2012).

The average sprint distance in European competitions ranges between 205 and 250 meters (Bradley et al., 2009; Dellal et al., 2011; Di Salvo et al., 2010). 86% of the sprint movements (≥7 m/s) are performed with a degree of curvature compared to the linear sprint (Caldbeck & Dos'Santos, 2022). The maximum sprint appears in the match with an average duration ranging from 4.9 s to 9 s and a distance of 30 to 55 meters. Most of the sprint is non-linear and without the ball, depending on the different tactical purposes, contextual factors, and the playing position (Oliva-Lozano et al., 2022).

Youth and professional soccer players perform approximately 305 to 726 CODs, path changes, turns, and swerves with an average of 19 seconds of rest. Most of these movements are performed at an angle of less than 90° to the right or left, followed by movements at an angle from 90° to 180°, while movements at an angle greater than 180° are few. For professionals, the playing position had a significant effect on the total number of turns and swerves and the amount of the angle of COD, but for young players, the change of direction is independent of the playing position, dominant leg, and anthropometric characteristics and appears equally between left and right and forward and backward(Bloomfield et al., 2007; Morgan et al., 2021)

Repeated multiple sprints require anaerobic and aerobic metabolic demands (Glaister, 2005). Repeated sprint ability (RSA) is a complex physical component that, according to Bishop et al.(2011), depends on two main determinants: 1) initial sprint performance, which is controlled by neuro-mechanical factors: stride length, related to power, flexibility, and ATP supply; and the second factor, stride frequency, related to neural factors (muscle activation and recruitment, intramuscular and intermuscular coordination); 2) recovery capabilities between multiple sprints, which are related to metabolic factors (e.g., oxidative capacity, PCrresynthesis, and the muscle pH regulating systems and h+ buffering) (Bishop et al., 2011; Ramirez-Campillo et al., 2021)

A change of direction is a preplanned movement that involves an acceleration and deceleration phase, then a turn followed by acceleration in a different direction. Taking into account the factors of muscle contraction during changing direction movements, a series of eccentric contractions occurs, followed by concentric contractions termed as the stretching-shortening cycle (SSC)(Castillo-Rodríguez et al., 2012). Change of direction is determined

Corresponding author: DERRAA Yazid **E-mail: derraa.yazid@univ-oeb.dz**

by technical factors such as foot placement, stride and body posture adjustments to accelerate and decelerate, and leg muscle qualities, which include strength, power, and reactive strength. It is also affected by body mass and fat percentage (Nygaard Falch et al., 2019; Young et al., 2002)

Sprinting without or with a COD requires activation of the SSC function of the muscle-tendon complex. Plyometric training focuses on stimulating the muscles to quickly switch from an eccentric to a concentric contraction, which enhances the neural drive of the SSC and improves performance in movements that use the rapid SSC. In addition, resulting in the ability to prevent injuries(Ramirez-Campillo et al., 2021; Wang & Zhang, 2016)

Plyometric training is recommended as an effective training method to improve COD ability because it is effective in developing both strength-oriented COD and velocity-oriented COD (Asadi et al., 2016; Nygaard Falch et al., 2019). Plyometric training also improves RSA parameters, especially the RSA average time and the RSA fastest time (Ramirez-Campillo et al., 2021). An important variable is the age or maturity status of the youth athletes. In terms of the effect of maturity stage, performance may be improved more in the middle (13–15.9 years of age) and post (16–18 years of age) stages of maturation(Asadi et al., 2017).

Plyometric training for eight weeks during the competitive period improves U17 soccer players' ability to perform repeated changes of direction (RCOD)(Hammami et al., 2016). Asadi et al (2016) suggest that plyometric programs be designed with two sessions per week and 72-hour rest periods between sessions, with 100 moderate-intensity jumps per session for seven weeks being an appropriate training dose to improve the change of direction ability of young athletes. Rather than using only one method, it is also beneficial to combine various forms of plyometric jumping or hopping with both or one leg, vertically or horizontally, in successive or separate maximal jumps (Asadi et al., 2016).

The inclusion of a plyometric training program during regular soccer training for a period of seven to ten weeks with a training volume of ten to sixteen sessions in the program resulted in a significant improvement in the linear and shuttle-repeated sprint ability parameters (RSA average time, RSA fastest time, RSA total time) for young and advanced soccer players aged 12 to 20 years(Borges et al., 2016; Buchheit et al., 2010; Ceylan & Demirkan, 2017; Negra et al., 2020).

Repeated sprinting with a change of direction is a common training method in team sports that require repeated changes of direction in competition (Sanchez-Sanchez et al., 2019). Preplanned multidirectional sprint drills at a variety of angles may result in significant improvements in change of direction speed in U15 soccer players(Born et al., 2016; Chaouachi et al., 2014). It also improves intermittent high intensity running performance among high-level soccer players aged 12 to 20 years (Sagelv et al., 2019). Six-week change-of-direction speed and technique modification training twice a week leads to technical improvements in cutting performance and movement quality, which may reduce potential injury risk in youth soccer players(Dos'Santos et al., 2019). Gains in RSA and

Corresponding author: YaizdDerraa **E-mail: derraa.yazid@univ-oeb.dz**

COD performanceafter change of direction training are greater for players with good aerobic fitness (VO2max ≥ 48 ml.kg^{-1}.min^{-1}) than for players with lower aerobic fitness (VO2max < 48 ml.kg^{-1}.min^{-1}) (Sanchez-Sanchez et al., 2019)

Combining plyometric training with change of direction drills for eight weeks at a frequency of two sessions per week during the competition period is sufficient to improve change of direction speed, repeated change of direction ability, and repeated shuttle sprint ability for young soccer players (Aloui, Hermassi, Hayes, et al., 2021; Aloui, Hermassi, Khemiri, et al., 2021).

Understanding the nature of the relationship between repeated sprint ability and repeated direction of change ability allows soccer coaches and conditioning practitioners to determine the specificity of training. RSA and RCOD abilities are separate physical components, but they are age-related, and performance varies between players depending on the level of training and competition. It is recommended to use the RSA/RCOD index to guide training priorities according to different ages and levels that require specific individualization of training (Dellal & Wong, 2013; Wong et al., 2012).

The RSA/RCOD index proposed by Wong et al. (2012) is a norm-referenced ratio that would help coaches prioritize RSA or RCOD ability training in soccer players. Players with an RSA/RCOD index less than (<0.59) need special training to improve their RCOD, whereas players with an RSA/RCOD index greater than (>0.59) require special training to improve their RSA. Besides that, the absolute performance of the players in relation to the reference values must be examined because the player may need to improve in both RSA and RCOD(Wong et al., 2012).

The aim of this study were to examine the effect of short-term plyometric training combined with multidirectional sprinting training on RCOD and RSA performance in soccer players U19.

The problematic of this study emerged in light of previous cited studies' findings. which can be expressed in this question: "**Is there a significant effect of combined plyometric training and sprinting with a change of direction on both RCOD and RSA abilities within and between groups**?"

It was hypothesized that after the training program, there would be significant differences in RCOD and RSA performance within the experimental group. It was also hypothesized that there would be significant differences in RCOD and RSA performance between the experimental group and the control group after the training intervention.

1. Methods and Materials

1.1 Experimental Approach

This study examined the effect of a six-week short-term training program that includes a combination of plyometric training and sprinting with CODs on RCOD and RSA in soccer players under 19 years old. The study population consists of soccer players under 19 years

Corresponding author: DERRAA Yazid **E-mail: derraa.yazid@univ-oeb.dz**

old who compete in Jijel State's Honors League during the 2022–2023 season. The experimental approach was used, with two samples randomly assigned as an experimental sample and a control sample. All players taking part in the study completed the RCOD test and the RSA test before and after the six-week training program intervention, at a frequency of two sessions per week in addition to the usual soccer training. The dependent variables (RCOD and RSA) were assessed with a repeated change of direction test (RCOD) and a repeated sprint ability test (RSA). To examine test-retest reliability, all participants were asked to perform RSA and RCOD tests by the same rater one week after the first testing session.

1.2 Procedures

This investigation was carried out from December to February. Participants trained three times per week between 6:00 and 7:30 p.m. and played one official game each Friday. The competitive season begins in week three after the start of the training program. All study interventions were made during the usual weekly training schedule. In the first week, a familiarization session was conducted to explain the training program, and verbal consent was taken from players to participate in the study. Anthropometric measures (standing height and body mass) and other characteristics(age, injury history, and years of training experience) were collected before testing sessions. Pre-tests were conducted a week before the start of the training program in two different sessions separated by two days. The training program began in the third week and lasted for six weeks, with a frequency of two sessions per week. Post-tests were conducted during the week following the end of the training program in two different sessions separated by one day. Then the obtained data were processed statistically.

1.3Subjects

Twenty players from all positions except goalkeepers, who belong to the same team competing in the Jijel State Honors League and have a playing experience of 3.9 ± 1.25years, participated and provided verbal informed consent to take part in this study, and they were assured that they could withdraw from the trial without penalty at any time. Subjects were randomly allocated to an experimental group (EG; n = 10, age: 17.6 ± 0.52 years, body mass: 64.01 ± 9.58, height: 173.1 ± 6.24cm, body mass index: 21.29 ± 2.26) and a control group (CG; n = 10, age: 17.5 ± 0.53 years, body mass: 66.59 ± 4.96 kg, height: 177.2 ± 8.39 m, body mass index: 21.26 ± 1.76). Participants were not injured.The anthropometric characteristics and training experience of the participants are presented in Table 1.

1.4 Training program

All participants were trained three times per week. During the six-week intervention, players in the experimental group were supplemented with an intervention program consisting of plyometric and multidirectional sprint training along with their usual soccer training. The control group kept their usual soccer training under the supervision of the club's coach. The interventional training program consists of two weekly sessions with an interval of 48 hours between sessions. The experimental group completed four workshops

Corresponding author: YaizdDerraa E-mail: derraa.yazid@univ-oeb.dz

that included a sequence of plyometric exercises and a multidirectional sprint. Each workshop begins with plyometric exercises (i.e., hurdle jumps, bounds, hops, countermovement jumps, and broad jumps) and ends with a sprint with a change of direction (i.e., 45°, 60°, 90°, 135°, 180°) or a curved sprint. Plyometric exercises performed lateral, Bilateral and Unilateral. The number of sets was progressively increased throughout the interventional program (from 4 to 5 sets) for each workshop, as was the total number of ground contacts per session (from 88 to 150 ground contacts per session). The recovery time between sets was gradually reduced (from 60s to 30s).

Table 1.Participants' characteristics

Characteristics	Experimental (n= 10)		Control (n= 10)	
	M	***SD***	***M***	***SD***
Age (year)	17.6	0.52	17.5	0.53
Body mass (kg)	64.01	9.58	66.59	4.96
Height (cm)	173.1	6.24	177.2	8.39
Body mass index (kg.m^{-2})	21.29	2.26	21.26	1.76
Training experience (year)	3.6	1.26	4.2	1.23

Note: The data are means (*M*) and standard deviations (*SD*).

1.5Testing Procedures

Participants took part in a familiarization session to reduce any learning effects. The second session was to record the anthropometric measurements (standing height and body mass) and other measurements (age, injury history, and years of training experience). All tests (pre- and post-tests) were conducted in two sessions separated by two days on an outdoor artificial turf soccer pitch while wearing soccer shoes, at the same time of day and under the same experimental conditions, at least 3 days after the most recent competition and 6–8 days after the most recent interventional program session, and were supervised and recorded by the same investigators. The order of the tests was the same on both occasions: RSA in the first session and RCOD in the second. Only one trial was recorded for further analysis. Testing was preceded by a standard 20-minute warm-up consisting of 10 minutes of low-intensity running followed by 10 minutes of dynamic stretching.

1.5.1 Anthropometrics measures

Anthropometric measurements included standing height and body mass, which were recorded using a stadiometer and a commercial digital scale (Accu-Measure Digital Scale). Body mass index (BMI) was calculated as body weight (in kilograms) divided by height (in meters) squared(Moreno et al., 2004).

1.5.1 Repeated Sprint Ability Tests

The Repeated Sprint Ability (RSA) test entailed six straight-line sprints (6 x 20 m) with a 25-second active recovery. During the active recovery, the subjects jogged slowly back to the starting line and waited for the next sprint. To eliminate the effect of reaction time on sprint time, the players began each sprint from a standing position 0.5 m behind the

Corresponding author: DERRAA Yazid **E-mail:** derraa.yazid@univ-oeb.dz

start line. Each player was encouraged verbally to give a maximal effort during all the RSA and RCOD tests (Dellal & Wong, 2013; Wong et al., 2012). The sprint time for 20 m was measured using a handheld digital stopwatch (Hetzler et al., 2008). The investigators used a second stopwatch to monitor recovery time.

1.5.2 Repeated Change of Direction Tests

The Repeated Change of Direction (RCOD) test entailed six sprints (20 m) with four 100° COD every 4 m and a 25-second active recovery with the same protocol as the RSA test (Dellal & Wong, 2013; Wong et al., 2012).

1.5.3 RSA and RCOD Tests parameters

The average time (AT), the fastest time (FT), and the total time (TT) were recorded from the RSA and RCOD test results. According to previous studies, the RSA/RCOD index proposed by Wong et al.(2012)has also been calculated for both the AT, BT, and TT and the RSA/RCOD index (Dellal& Wong, 2013; Wong et al., 2012).The percentage decrement score (%Dec) was calculated using the formula recommended byGlaister et al. (2008)as the most valid and reliable approach to assess fatigue index in repeated sprint tests(Glaister et al., 2008).

Fatigue = The percentage decrement score.

Calculation: Fatigue = [100 × (total sprint time ÷ ideal sprint time)]– 100

Total sprint time = Sum of sprint times from all sprints.

Ideal sprint time = The number of sprints × fastest sprint time.

1.6Statistical analysis

Statistical analysis was performed using SPSS version 29.0 for Windows (SPSS Inc., IBM, Armonk, NY, USA). Means and Standard deviations were calculated using the standard statistical method, and they are reported as mean (*M*) and Standard deviation(±*SD*). The data were tested for normal distribution using the Shapiro-Wilk test. The homogeneity of variance was determined using Levene's test. After confirming normal distribution, paired-sample t-tests were used to investigate differences within each group, and independent sample t-tests were used to investigate intergroup differences at baseline and post-intervention; if normal distribution was not assumed, the Mann-Whitney U test was used (Pallant, 2020). Effect size within and between groups are reported as Cohen's d, and the standardizer of Cohen's d was calculated using the standard deviation of the difference in SPSS. Cohen's d can be classified as trivial (0.20), small (0.2–0.6), moderate (0.6–1.2), and large (1.2–2.0) (Hopkins et al., 2009)

A two-way mixed effects intra-class correlation coefficient (ICC), with absolute agreement and reporting 95% confidence intervals (95%CI), was used alongside the coefficient of variation (CV) to evaluate relative test–retest reliability. The interpretation of ICC values was in accordance with the previous guidelines by Koo and Li(2016), where values greater than 0.90, between 0.75 and 0.9, between 0.5 and 0.75, and less than 0.5 are indicative of excellent, good, moderate, and poor reliability, respectively. As reported in a previous study by Wong et al. (2012), coefficients of variation lower than 10% were considered acceptable. The level of significance was set at $P < 0.05$.

Corresponding author: YaizdDerraa **E-mail:** derraa.yazid@univ-oeb.dz

Percentage changes were calculated as [(post-training value − pre-training value)/pre-training value] ×100 (Hammami et al., 2019).

2. Results

2.1 Normal Distribution and Homogeneity ofVariance

The Shapiro-Wilk test revealed that all data were normally distributed (p > .05), with the exception of the age variable (p < .001). In terms of variance heterogeneity in Levene's test, the RSA-%Dec (*p* =.032), RSA/RCOD (TT) index (*p* =.008), RSA/RCOD (FT) index (*p* =.009), and RSA/RCOD (AT) index (*p* =.008) post intervention variables were not homogeneous. In other cases, variance equality is assumed (*p*< .05).

2.2 Differences in characteristics between subjects

The results obtained from an independent sample t-test showed there were no statistically significant baseline differences between groups (*p*>.05) with regards to height, body mass, body mass index, and training experience. The Mann-Whitney U showed no significant differences between groups in the age variable (*p* = 1).

2.3 Test-retest reliabilities

The intraclass correlation coefficient (ICC) for test-retest for RSA-TT, RSA-FT, RSA-AT, RCOD-TT, RCOD-FT, and RCOD-AT ranged from moderate to excellent reliability, and their CV values were lower than 10%. The RSA-%Dec and RCOD-%Dec showed poor reliability and a CV greater than 10%. See table 2.

Table 2.Interclass correlation coefficient (ICC, 95% confidence intervals (95% CI)) and coefficient of variation (CV) of all RSA and RCOD parameters for test-retest reliabilities

Measures	ICC	95% CI	% CV
RSA-TT	0.966	0.85 - 0.99	4.04
RSA-FT	0.903	0.67 - 0.97	3.23
RSA-AT	0.965	0.85 - 0.99	4.04
RSA-%Dec	0.843	0.48 - 0.96	37.45
RCOD-TT	0.950	0.82 - 0.99	4.88
RCOD -FT	0.916	0.71 - 0.98	5.47
RCOD -AT	0.951	0.82 - 0.99	4.86
RCOD -%Dec	0.215	-0.31 - 0.70	38.91

Note: RSA = repeated sprint ability; RCOD = repeated change of direction; TT = total time; AT = average time; FT = the fastest time; %Dec = percentage decrement: ICC = Interclass correlation coefficient; 95% CI = 95% confidence intervals; % CV = coefficient of variation.

2.4 RCOD and RSA performance differences between groups at baseline

The independent sample t-test showed no meaningful between-group differences at baseline for any of the analyzed parameters. See table 3.

2.5 Training Effect on Repeated Change of Direction Ability

The statistical analysis within the experimental group is shown in Table 4. We found meaningful improvements ranging from moderate to large in effect size from pre- to post-

Corresponding author: DERRAA Yazid **E-mail:** derraa.yazid@univ-oeb.dz

intervention on RCOD-TT, *t*(9) = 4.28, *p* =.002, *d* = 1.36, -8.38%; RCOD-FT, *t*(9) = 3.54, *p* =.006, *d* = 1.12, -7.41%; and RCOD-AT, *t*(9) = 4.29, *p* =.002, *d* = 1.36, -8.39%; Participants in the control group, on the other hand, showed no significant change in all RCOD measures from pre- to post-training intervention.

Table 3.RCOD and RSA performance differences between groups at baseline

Tests parameters	Independent sample t-test				
	Experimental (n= 10)		Control (n=10)		*P*-value
	M	***SD***	***M***	***SD***	
RSA-TT	20.26	1.32	20.11	0.89	0.775
RSA-FT	3.24	0.21	3.17	0.10	0.396
RSA-AT	3.38	0.22	3.35	0.15	0.787
RSA-%Dec	4.42	1.66	5.46	2.98	0.349
RCOD-TT	39.39	3.59	38.95	1.98	0.739
RCOD –FT	6.32	0.58	6.23	0.34	0.694
RCOD –AT	6.57	0.60	6.49	0.33	0.732
RCOD -%Dec	3.93	1.53	4.28	1.31	0.598
RSA/RCOD (TT) index	0.52	0.04	0.52	0.02	0.946
RSA/RCOD (FT) index	0.51	0.04	0.51	0.02	0.842
RSA/RCOD (AT) index	0.52	0.04	0.52	0.02	0.946

Note: The data are means (*M*) and standard deviations (*SD*). RSA = repeated sprint ability; RCOD = repeated change of direction; TT = total time; AT = average time; FT = the fastest time; %Dec = percentage decrement; P-value in bold = significant differences (criteria: $p < 0.05$).

2.6 Training Effect on Repeated Change of DirectionAbility

The statistical analysis within the experimental group is shown in Table 4. We found meaningful improvements ranged from moderate to large effect size from pre- to post-intervention on RCOD-TT, *t*(9) = 4.28, *p* =.002, *d* = 1.36, Δ = -8.38%; RCOD-FT, *t*(9) = 3.54, *p* =.006, *d* = 1.12, Δ-7.41%; and RCOD-AT, *t*(9) = 4.29, *p* =.002, *d* = 1.36, Δ = -8.39%. Participants in the control group, on the other hand, showed no significant change in all RCOD measures from pre- to post-training intervention.

2.7 Training Effect on Repeated Sprint Ability

Significant improvements were found in three RSA parameters with a moderate effect size after the training intervention: RSA-TT, *t*(9) = 3.08, *p* =.013, *d* = 0.97, RSA-FT, *t*(9) = 2.47, *p* =.036, *d* = 0.78, and RSA-AT, *t*(9) = 3.03, *p* =.014, *d* = 0.96. No significant differences were found for the other RSA performance measures. The training program showed a decrease in RSA-TT by (Δ-5.07%), RSA-FT by (Δ-4.52%), and RSA-AT by (Δ-4.98%). The RSA-%Dec has a (Δ-13.98%) percentage change with no significant difference.

While there were no significant changes in the control group for all RSA parameters, on the other hand, no significant differences were found in the control group for all RSA measurements.

Corresponding author: YaizdDerraa E-mail: derraa.yazid@univ-oeb.dz

2.8 Training Effect on RSA/RCOD index

The changes that occurred in the RSA/RCOD index were small to moderate but not significantly different within and between groups.See tables 3 and 4.

2.9 Comparison RCOD performance changes between groups

Between-group analyses are presented in table 6. Compared to the control group, the participants in the experimental group gained moderate improvements greater than the control group only in the following RCOD measures: RCOD-TT, $t(18) = -2.51$, $p = .022$, $d = 1.12$; and RCOD-AT, $t(18) = -2.51$, $p = .022$, $d = 1.12$.

2.10 Comparison RSA performance changes between groups

Performance in RSA was improved more in the experimental group compared with the control group, with a moderate effect size(RSA-TT, $t(9) = -2.27$, $p = 0.036$, $d = 1.01$, and RSA-AT, $t(9) = -2.23$, $p = 0.038$, $d = 1$), except the RSA %Dec did not show meaningful differences.

Table 4.RCOD and RSA performance differences within the experimental group at baseline and after training interventions

Tests parameters	Experimental group (n = 10)					Paired t-Test		
	Pre		Post		%Δ	*df*	*P*-value	*ES*
	M	*SD*	*M*	*SD*				Cohen's *d*
RSA-TT	20.50	1.19	19.46	0.78	-5.07	9	**0.013**	0.97 (moderate)
RSA-FT	3.27	0.19	3.12	0.12	-4.52	9	**0.036**	0.78 (moderate)
RSA-AT	3.42	0.20	3.25	0.13	-4.98	9	**0.014**	0.96 (moderate)
RSA %Dec	4.42	1.66	3.80	1.31	-13.98	9	0.323	0.33 (small)
RCOD-TT	39.48	3.59	36.17	2.57	-8.38	9	**0.002**	1.36 (large)
RCOD-FT	6.33	0.58	5.86	0.40	-7.41	9	**0.006**	1.12 (moderate)
RCOD-AT	6.58	0.60	6.03	0.43	-8.39	9	**0.002**	1.36 (large)
RCOD-%Dec	3.97	1.51	2.83	1.08	-28.63	9	0.098	0.58 (small)
RSA/RCOD (TT) index	0.52	0.04	0.53	0.04	1.72	9	0.389	-0.29 (small)
RSA/RCOD (FT) index	0.52	0.04	0.53	0.04	2.51	9	0.249	-0.39 (small)
RSA/RCOD (AT) index	0.52	0.04	0.53	0.04	1.72	9	0.389	-0.29 (small)

Note: The data are means (*M*) and standard deviations (*SD*). RSA = repeated sprint ability; RCOD = repeated change of direction; TT = total time; AT = average time; FT = the fastest time; %Dec = percentage decrement; %Δ = Percentage changes; *df* = degree of freedom; *ES* = effect size;*P*-value in bold =significant differences (criteria: $p < 0.05$).

3. Discussion

3.1 Training Effect on Repeated Change of Direction Ability

The investigated training program showed meaningful improvements with a moderate effect size within the experimental group in two measures of RCOD. The magnitude of the training intervention effectiveness ranged from moderate on RCOD-FT, $t(9) = 3.54$, $p = .006$, $d = 1.12$, -7.41%, to large on RCOD-TT, $t(9) = 4.28$, $p = .002$, $d = 1.36$, -8.38%, and RCOD-AT, $t(9) = 4.29$, $p = .002$, $d = 1.36$, -8.39%. Furthermore, players who have been exposed to

Corresponding author: DERRAA Yazid E-mail: derraa.yazid@univ-oeb.dz

the training program achieved greater improvements on RCOD-TT, $t(18) = -2.51$, $p = .022$, and $d = 1.12$; and RCOD-AT, $t(18) = -2.51$, $p = .022$, and $d = 1.12$.

Table 5.RCOD and RSA performance differences within the control group at baseline and after training interventions

Tests parameters	Control group (n = 10)						Paired t-Test	
	Pre		Post		%Δ		*P*-value	*ES* Cohen's *d*
	M	*SD*	*M*	*SD*				
RSA-TT	19.87	0.96	19.76	0.92	-0.56	9	0.096	0.59 (small)
RSA-FT	3.14	0.09	3.14	0.11	-0.06	9	0.900	0.04 (trivial)
RSA-AT	3.31	0.16	3.30	0.15	-0.54	9	0.108	0.56 (small)
RSA-%Dec	5.46	2.98	4.95	2.31	-9.40	9	0.386	0.29 (small)
RCOD-TT	38.87	1.96	38.44	2.18	-1.11	9	0.269	0.37 (small)
RCOD-FT	6.21	0.33	6.18	0.38	-0.58	9	0.522	0.21 (small)
RCOD-AT	6.48	0.32	6.41	0.36	-1.11	9	0.271	0.37 (small)
RCOD -%Dec	4.28	1.31	3.73	1.85	-12.79	9	0.458	0.25 (small)
RSA/RCOD (TT) index	0.51	0.02	0.51	0.02	0.20	9	0.798	-0.08 (trivial)
RSA/RCOD (FT) index	0.51	0.02	0.51	0.02	0.39	9	0.619	-0.16 (trivial)
RSA/RCOD (AT) index	0.51	0.02	0.51	0.02	0.20	9	0.798	-0.08 (trivial)

Note: The data are means (*M*) and standard deviations (*SD*). RSA = repeated sprint ability; RCOD = repeated change of direction; TT = total time; AT = average time; FT = the fastest time; %Dec = percentage decrement; %Δ = Percentage changes; *df* = degree of freedom; *ES* = effect size; P-value in bold = significant differences (criteria: $p < 0.05$).

Table 6.RCOD and RSA performance differences between groups after training intervention

Tests parameters	Independent sample t-test						
	Experimental (n= 10)		Control (n=10)		*df*	P-value	*ES* Cohen's *d*
	M	*SD*	*M*	*SD*			
RSA-TT	19.22	0.76	20.00	0.77	18	**0.036**	1.01 (moderate)
RSA-FT	3.10	0.11	3.17	0.10	18	0.149	0.67 (moderate)
RSA-AT	3.21	0.13	3.33	0.13	18	**0.038**	1 (moderate)
RSA-%Dec	3.80	1.31	4.95	2.31	18	0.195	0.61 (moderate)
RCOD-TT	36.17	2.57	38.71	1.91	18	**0.022**	1.12 (moderate)
RCOD -FT	5.86	0.40	6.20	0.36	18	0.061	0.89 (moderate)
RCOD -AT	6.03	0.43	6.45	0.32	18	**0.022**	1.12 (moderate)
RCOD -%Dec	2.83	1.08	3.73	1.85	18	0.202	-0.59 (small)
RSA/RCOD (TT) index	0.53	0.04	0.52	0.02	18	0.270	-0.51 (small)
RSA/RCOD (FT) index	0.53	0.04	0.51	0.02	18	0.181	-0.63 (moderate)
RSA/RCOD (AT) index	0.53	0.04	0.52	0.02	18	0.270	-0.51 (small)

Note: The data are means (*M*) and standard deviations (*SD*). RSA = repeated sprint ability; RCOD = repeated change of direction; TT = total time; AT = average time; FT = the fastest time; %Dec = percentage decrement; %Δ = Percentage changes; *df* = degree of freedom; *ES* = effect size; P-value in bold = significant differences (criteria: $p < 0.05$).

Corresponding author: YaizdDerraa E-mail: derraa.yazid@univ-oeb.dz

Similarly, a study on under-15 male soccer players found that combining plyometric training with change of direction, for eight weeks at a frequency of two sessions per week is sufficient to significantly improve repeated change of direction on the fastest time (*ES* = 2.01, -7.85%) and average time (*ES* = 2.02, -7.85%), as well as change of direction speed in the (4 × 5 m) test (*ES* = 2.01, -7.85%) (Aloui, Hermassi, Khemiri, et al., 2021). Plyometric raining during 8 weeks improved RCOD-TT (*ES* = 1.85) and RCOD-FT (*ES* = 1.98) in junior soccer players (Hammami et al., 2016). Performance in RCOD ability showed large significant gains for soccer players under 19 years old after 8-week intervention of combined plyometric and short sprint training (*ES* = 1.38) (Aloui, Souhail, et al., 2021)

Nygaard Falch et al. (2019) reported that it is prudent to consider the specificity of the training and that choosing the optimal type of training depends on the types of direction changes involved in the competition. In order to increase the effectiveness of training, it is preferable to perform exercises that are similar to muscle work in terms of duration and the angle of directional change during competition (Nygaard Falch et al., 2019).

With regard to the influence of maturation stage, it was considered one of the important variables in COD performance gains after plyometric training. A meta-analysis reported that there is a tendency toward greater gains in change of direction ability in older youth athletes in the POST (16 to 18 years old) and MID (13 to 15.9 years old) stages of maturation (MID, *ES* = 0.95; POST, *ES* = 0.99; PRE, *ES* = 0.68) compared with younger athletes in the PRE (10 to 12.9). Based on these findings, the players in the current study are in the post-maturation stage, which means they may have had discernible improvements in RCOD performance measures (Asadi et al., 2017).

Optimal change of direction Performance is related to a relatively short ground contact time, which refers to a rapid SSC and In addition to postural adjustments in hip, knee, and ankle joints. Plyometric training that targets reactive strength and leg muscle power would enhances change of direction speed (Young et al., 2002). Exercises that stimulate the SSC cause improvements in the muscle-tendon unit, allowing it to produce maximum force in the shortest amount of time, thereby developing muscle power (Beato et al., 2018; Bedoya et al., 2015; Markovic et al., 2007)

This improvement in RCOD performances could be explained by the adaptations induced by plyometric training on SSC function, the muscle-tendon complex, neural drive, inter- and intramuscular coordination (Beato et al., 2018; Ramirez-Campillo et al., 2021; Wang & Zhang, 2016)**,** and the specificity of COD training in optimizing the technical factors that are involved in the execution of COD movements (Dos'Santos et al., 2019)

3.2 Training Effect on Repeated Sprint Ability

The results demonstrated that 6 weeks of plyometric and change of direction drills alongside regular soccer training induced moderate performance improvements in RSA-TT, $t(9) = 3.08$, $p = .013$, $d = 0.97$, Δ-5.07%, RSA-FT, $t(9) = 2.47$, $p = .036$, $d = 0.78$, Δ-4.52%, and RSA-AT, $t(9) = 3.03$, $p = .014$, $d = 0.96$, Δ -4.98% measures within the experimental group. Independent sample t-tests analysis revealed moderate improvements in two RSA

Corresponding author: DERRAA Yazid **E-mail:** derraa.yazid@univ-oeb.dz

measures compared to the control group: RSA-TT, *t*(9) = -2.27, *p* =.036, *d* = 1.01, and RSA-AT, *t*(9) = -2.23, *p* =.038 and *d* = 1.

Repeated sprint ability depends on two basic determinants: the initial sprint performance and the recovery capabilities between multiple sprints. Improving these two factors can help enhance performance in RSA (Bishop et al., 2011). Combined plyometric and change of direction drills for eight weeks significantly enhance performance in the 5 m and 20 m sprints, which could be considered the initial sprint performance factor, in addition to a significant improvement in the repeated shuttle sprint ability (20 m + 20 m x 6) with a passive rest of 20 seconds for soccer players under 17 years old. As for the RSA-%Dec variable, the results of the current study indicate that there is a non-significant decrease in the percentage decrement. Similar results indicated that there was no significant change in RSA-%Dec (Aloui, Hermassi, Hayes, et al., 2021).Repeated shuttle sprint ability (fastest time, *ES* = 1.64 and average time, ES = 1.64) and sprint performance over a distance of 20 m (*ES* = 1.38), significantly improved after a training program that combined plyometric and short sprint training(Aloui et al., 2022; Aloui, Hermassi, Hayes, et al., 2021). Furthermore, Beato et al. (2019) found that very short-term repeated shuttle sprint training (six sessions over two weeks) for soccer players competing at the amateur level, whose average age is 21, had a moderate effect size (*ES* = 0.65) on RST-FT(Beato et al., 2019).

Repeated sprints with direction change training improved RSA performance (30 m × 6) with 25 seconds of activity recovery between sprints (*ES* = 0.16-0.38) in athletes with high aerobic fitness but not in athletes with low aerobic fitness (*ES* = 0.03-0.13). The lack of information about the aerobic fitness level of participants in the current study makes us confused about the effect of the initial aerobic fitness level on performance gains after the intervention(Sanchez-Sanchez et al., 2019).

With regard to the effect of isolated plyometric training on RSA performance, a study conducted by Borges et al. (2016)that examined the effect of twelve plyometric training sessions over seven weeks was found to improve performance on the RSA-FT, *d* = 0.21, and the RSA-AT, *d* = 0.16, interpreted as small and trivial, respectively (Borges et al., 2016).In another study, consisting of horizontal and vertical plyometric jump training lasting 8 weeks, large performance improvements were seen in theRSA-TT (*d* = 1.6) (Negra et al., 2020). In terms of the effect of short-term training programs, plyometric training three times per week for six weeks significantly improved the RSA-AT with a small effect size of *ES* = 0.23 (Krakan et al., 2020). Also, one session of explosive strength training for ten weeks significantly enhances performance in the 30 m sprint, the average time, and the fastest time for repeated shuttle sprints (15 m + 15 m x 6) every 20 seconds (Buchheit et al., 2010).

Plyometric training develops eccentric and concentric muscle contractions and improves muscular, tendon, and nerve functions (Wang & Zhang, 2016). In other words, exercises that stimulate the SSC enhance the ability of the neural and musculotendinous systems to produce maximal force in the shortest amount of time (Beato et al., 2018). Further, plyometric exercises optimize the rate of force development and muscle power due to the use of the SSC of the muscle–tendon complex. Improvements in repeated sprint

Corresponding author: YaizdDerraa E-mail: derraa.yazid@univ-oeb.dz

ability after a plyometric training program could be explained by adaptations induced by plyometric training, including improved regulation of the muscle–tendon complex, increased neural drive to agonist muscles, enhanced intermuscular coordination(Ramirez-Campillo et al., 2021),and enhancement of the ability of the neural and musculotendinous systems to produce maximal force in the shortest amount of time(Beato et al., 2018).

3.2 Training Effect on RSA/RCOD index

The RSA/RCOD is used to determine the priority of physical conditioning on RSA or RCOD training. The RSA/RCOD is used to determine the priority of physical conditioning on RSA or RCOD training. In comparison to the control group, the current results showed a moderate but non-significant effect on the RSA/RCOD (FT) index (*ES* = -0.63). while the other indices had a small effect size either within or between groups. This could explain improvements simultaneously on both RSA and RCOD. A previous study reported that the RSA/RCOD index ranged between 0.51 and 0.60 among U15, U19, and professional soccer players. According to this finding, deciding between RSA and RCOD as a priority is determined by age, playing position, physical fitness level, and training system(Wong et al., 2015)

4. Conclusion

In conclusion, short-term combined plyometric and change of direction training at a frequency of two sessions per week with an increased total number of ground contacts per session (from 88 to 150 ground contacts per session) and sets (from 16 to 25 sets) per session would be sufficient to enhance RCOD and RSA parameters (total time, fastest time, and average time), but not percentage decrement (fatigue index) and the RSA/RCOD index. The RSA/RCOD index is useful for coaches and strength and conditioning practitioners to direct physical training toward either more specific RSA or RCOD training while taking into account the absolute performance of players.

5. References

1. Aloui, G., Hermassi, S., Bartels, T., Hayes, L. D., Bouhafs, E. G., Chelly, M. S., & Schwesig, R. (2022). Combined Plyometric and Short Sprint Training in U-15 Male Soccer Players: Effects on Measures of Jump, Speed, Change of Direction, Repeated Sprint, and Balance. *Frontiers in Physiology*, *13*(February), 1–9. https://doi.org/10.3389/fphys.2022.757663
2. Aloui, G., Hermassi, S., Hayes, L. D., Sanal Hayes, N. E. M., Bouhafs, E. G., Chelly, M. S., & Schwesig, R. (2021). Effects of Plyometric and Short Sprint with Change-of-Direction Training in Male U17 Soccer Players. *Applied Sciences*, *11*(11), 4767. https://doi.org/10.3390/app11114767
3. Aloui, G., Hermassi, S., Khemiri, A., Bartels, T., Hayes, L. D., Bouhafs, E. G., Souhaiel Chelly, M., & Schwesig, R. (2021). An 8-Week Program of Plyometrics and Sprints with Changes of Direction Improved Anaerobic Fitness in Young Male Soccer Players. *International Journal of Environmental Research and Public Health*, *18*(19), 10446. https://doi.org/10.3390/ijerph181910446
4. Aloui, G., Souhail, H., Hayes, L. D., Bouhafs, E. G., Chelly, M. S., & Schwesig, R. (2021). Effects of Combined Plyometric and Short Sprints Training on Athletic Performance of Male U19 Soccer Players. *Frontiers in Psychology*, *12*(September), 1–11. https://doi.org/10.3389/fpsyg.2021.714016
5. Asadi, A., Arazi, H., Ramirez-Campillo, R., Moran, J., & Izquierdo, M. (2017). Influence of Maturation Stage on Agility Performance Gains after Plyometric Training: A Systematic Review and Meta-analysis. *Journal of Strength and Conditioning Research*, *31*(9), 2609–2617. https://doi.org/10.1519/JSC.0000000000001994
6. Asadi, A., Arazi, H., Young, W. B., & de Villarreal, E. S. (2016). The Effects of Plyometric Training on Change-of-Direction Ability: A Meta-Analysis. *International Journal of Sports Physiology and Performance*, *11*(5), 563–573. https://doi.org/10.1123/ijspp.2015-0694
7. Beato, M., Bianchi, M., Coratella, G., Merlini, M., & Drust, B. (2018). Effects of Plyometric and Directional Training on Speed and Jump Performance in Elite Youth Soccer Players. *Journal of Strength and Conditioning*

Corresponding author: DERRAA Yazid **E-mail:** derraa.yazid@univ-oeb.dz

Research, *32*(2), 289–296. https://doi.org/10.1519/JSC.0000000000002371
8. Beato, M., Coratella, G., Bianchi, M., Costa, E., & Merlini, M. (2019). Short-Term Repeated-Sprint Training (Straight Sprint vs. Changes of Direction) in Soccer Players. *Journal of Human Kinetics*, *70*(1), 183–190. https://doi.org/10.2478/hukin-2019-0040
9. Bedoya, A. A., Miltenberger, M. R., & Lopez, R. M. (2015). Plyometric Training Effects on Athletic Performance in Youth Soccer Athletes: A Systematic Review. *Journal of Strength and Conditioning Research*, *29*(8), 2351–2360. https://doi.org/10.1519/JSC.0000000000000877
10. Bishop, D., Girard, O., & Mendez-Villanueva, A. (2011). Repeated-sprint ability - part II: recommendations for training. *Sports Medicine (Auckland, N.Z.)*, *41*(9), 741–756. https://doi.org/10.2165/11590560-000000000-00000
11. Bloomfield, J., Polman, R., & O'Donoghue, P. (2007). Physical demands of different positions in FA Premier League soccer. *Journal of Sports Science and Medicine*, *6*(1), 63–70.
12. Borges, J. H., Conceição, M. S., Vechin, F. C., Pascoal, E. H. F., Silva, R. P., & Borin, J. P. (2016). The effects of resisted sprint vs. plyometric training on sprint performance and repeated sprint ability during the final weeks of the youth soccer season. *Science & Sports*, *31*(4), e101–e105. https://doi.org/10.1016/j.scispo.2015.10.004
13. Born, D. P., Zinner, C., Düking, P., & Sperlich, B. (2016). Multi-directional sprint training improves change-of-direction speed and reactive agility in young highly trained soccer players. *Journal of Sports Science and Medicine*, *15*(2), 314–319.
14. Bradley, P. S., Sheldon, W., Wooster, B., Olsen, P., Boanas, P., & Krustrup, P. (2009). High-intensity running in English FA Premier League soccer matches. *Journal of Sports Sciences*, *27*(2), 159–168. https://doi.org/10.1080/02640410802512775
15. Buchheit, M., Mendez-Villanueva, A., Delhomel, G., Brughelli, M., & Ahmaidi, S. (2010). Improving Repeated Sprint Ability in Young Elite Soccer Players: Repeated Shuttle Sprints Vs. Explosive Strength Training. *Journal of Strength and Conditioning Research*, *24*(10), 2715–2722. https://doi.org/10.1519/JSC.0b013e3181bf0223
16. Caldbeck, P., & Dos'Santos, T. (2022). A classification of specific movement skills and patterns during sprinting in English Premier League soccer. *PLOS ONE*, *17*(11), e0277326. https://doi.org/10.1371/journal.pone.0277326
17. Castillo-Rodríguez, A., Fernández-García, J. C., Chinchilla-Minguet, J. L., & Carnero, E. Á. (2012). Relationship Between Muscular Strength and Sprints with Changes of Direction. *Journal of Strength and Conditioning Research*, *26*(3), 725–732. https://doi.org/10.1519/JSC.0b013e31822602db
18. Ceylan, L., & Demirkan, E. (2017). Effect of Plyometric Training on Repeated Sprint Performance in Amateur Soccer Players. *European Journal of Physical Education and …*, *December*. https://doi.org/10.5281/zenodo.1115668
19. Chaouachi, A., Chtara, M., Hammami, R., Chtara, H., Turki, O., & Castagna, C. (2014). Multidirectional sprints and small-sided games training effect on agility and change of direction abilities in youth soccer. *Journal of Strength and Conditioning Research*, *28*(11), 3121–3127. https://doi.org/10.1519/JSC.0000000000000505
20. Dellal, A., Chamari, K., Wong, D. P., Ahmaidi, S., Keller, D., Barros, R., Bisciotti, G. N., & Carling, C. (2011). Comparison of physical and technical performance in European soccer match-play: Fa Premier League and La Liga. *European Journal of Sport Science*, *11*(1), 51–59. https://doi.org/10.1080/17461391.2010.481334
21. Dellal, A., & Wong, D. P. (2013). Repeated Sprint and Change-of-Direction Abilities in Soccer Players. *Journal of Strength and Conditioning Research*, *27*(9), 2504–2508. https://doi.org/10.1519/JSC.0b013e31827f540c
22. Di Salvo, V., Baron, R., González-Haro, C., Gormasz, C., Pigozzi, F., & Bachl, N. (2010). Sprinting analysis of elite soccer players during European Champions League and UEFA Cup matches. *Journal of Sports Sciences*, *28*(14), 1489–1494. https://doi.org/10.1080/02640414.2010.521166
23. Dolci, F., Hart, N. H., Kilding, A. E., Chivers, P., Piggott, B., & Spiteri, T. (2020). Physical and Energetic Demand of Soccer: A Brief Review. *Strength and Conditioning Journal*, *42*(3), 70–77. https://doi.org/10.1519/SSC.0000000000000533
24. Dos'Santos, T., McBurnie, A., Comfort, P., & Jones, P. A. (2019). The Effects of Six-Weeks Change of Direction Speed and Technique Modification Training on Cutting Performance and Movement Quality in Male Youth Soccer Players. *Sports*, *7*(9), 205. https://doi.org/10.3390/sports7090205
25. Faude, O., Koch, T., & Meyer, T. (2012). Straight sprinting is the most frequent action in goal situations in professional football. *Journal of Sports Sciences*, *30*(7), 625–631. https://doi.org/10.1080/02640414.2012.665940
26. Glaister, M. (2005). Multiple sprint work : physiological responses, mechanisms of fatigue and the influence of aerobic fitness. *Sports Medicine*, *35*(9), 757–777. https://doi.org/10.2165/00007256-200535090-00003
27. Glaister, M., Howatson, G., Pattison, J. R., & McInnes, G. (2008). The Reliability and Validity of Fatigue Measures During Multiple-Sprint Work: An Issue Revisited. *Journal of Strength and Conditioning Research*, *22*(5), 1597–1601. https://doi.org/10.1519/JSC.0b013e318181ab80
28. Hammami, M., Gaamouri, N., Aloui, G., Shephard, R. J., & Chelly, M. S. (2019). Effects of combined plyometric and short sprint with change-of-direction training on athletic performance of male u15 handball players. *Journal of Strength and Conditioning Research*, *33*(3), 662–675. https://doi.org/10.1519/jsc.0000000000002870
29. Hammami, M., Negra, Y., Aouadi, R., Shephard, R. J., & Chelly, M. S. (2016). Effects of an In-season Plyometric Training Program on Repeated Change of Direction and Sprint Performance in the Junior Soccer Player. *Journal of Strength and Conditioning Research*, *30*(12), 3312–3320. https://doi.org/10.1519/JSC.0000000000001470
30. Hetzler, R. K., Stickley, C. D., Lundquist, K. M., & Kimura, I. F. (2008). Reliability and Accuracy of Handheld Stopwatches Compared With Electronic Timing in Measuring Sprint Performance. *Journal of Strength and Conditioning Research*, *22*(6), 1969–1976. https://doi.org/10.1519/JSC.0b013e318185f36c
31. Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise*, *41*(1), 3–12. https://doi.org/10.1249/MSS.0b013e31818cb278

Corresponding author: YaizdDerraa E-mail: derraa.yazid@univ-oeb.dz

32. Koo, T. K., & Li, M. Y. (2016). A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. *Journal of Chiropractic Medicine*, *15*(2), 155–163. https://doi.org/10.1016/j.jcm.2016.02.012
33. Krakan, I., Milanovic, L., & Belcic, I. (2020). Effects of Plyometric and Repeated Sprint Training on Physical Performance. *Sports*, *8*(7), 91. https://doi.org/10.3390/sports8070091
34. Markovic, G., Jukic, I., Milanovic, D., & Metikos, D. (2007). Effects of sprint and plyometric training on muscle function and athletic performance. *Journal of Strength and Conditioning Research*, *21*(2), 543–549. https://doi.org/10.1519/R-19535.1
35. Martínez-Hernández, D., Quinn, M., & Jones, P. (2022). Linear advancing actions followed by deceleration and turn are the most common movements preceding goals in male professional soccer. *Science and Medicine in Football*, *00*(00), 1–9. https://doi.org/10.1080/24733938.2022.2030064
36. Moreno, L. A., León, J. F., Serón, R., Mesana, M. I., & Fleta, J. (2004). Body composition in young male football (soccer) players. *Nutrition Research*, *24*(3), 235–242. https://doi.org/10.1016/j.nutres.2003.10.006
37. Morgan, O. J., Drust, B., Ade, J. D., & Robinson, M. A. (2021). Change of direction frequency off the ball: new perspectives in elite youth soccer. *Science and Medicine in Football*, *27*(2), 1–10. https://doi.org/10.1080/24733938.2021.1986635
38. Negra, Y., Chaabene, H., Fernandez-Fernandez, J., Sammoud, S., Bouguezzi, R., Prieske, O., & Granacher, U. (2020). Short-Term Plyometric Jump Training Improves Repeated-Sprint Ability in Prepuberal Male Soccer Players. *Journal of Strength and Conditioning Research*, *34*(11), 3241–3249. https://doi.org/10.1519/JSC.0000000000002703
39. Nygaard Falch, H., Guldteig Rædergård, H., & van den Tillaar, R. (2019). Effect of Different Physical Training Forms on Change of Direction Ability: a Systematic Review and Meta-analysis. *Sports Medicine - Open*, *5*(1), 53. https://doi.org/10.1186/s40798-019-0223-y
40. Oliva-Lozano, J. M., Fortes, V., López-Del Campo, R., Resta, R., & Muyor, J. M. (2022). When and how do professional soccer players experience maximal intensity sprints in LaLiga? *Science and Medicine in Football*, 1–9. https://doi.org/10.1080/24733938.2022.2100462
41. Pallant, J. (2020). *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS* (7th ed). Routledge.
42. Ramirez-Campillo, R., Gentil, P., Negra, Y., Grgic, J., & Girard, O. (2021). Effects of Plyometric Jump Training on Repeated Sprint Ability in Athletes: A Systematic Review and Meta-Analysis. *Sports Medicine*, *51*(10), 2165–2179. https://doi.org/10.1007/s40279-021-01479-w
43. Sagelv, E. H., Selnæs, I., Pedersen, S., Pettersen, S. A., Randers, M. B., & Welde, B. (2019). Effects of linear versus changes of direction repeated sprints on intermittent high intensity running performance in high-level junior football players over an entire season: A randomized trial. *Sports*, *7*(8), 9–12. https://doi.org/10.3390/sports7080189
44. Sanchez-Sanchez, J., Ramirez-Campillo, R., Petisco, C., Gonzalo-Skok, O., Rodriguez-Fernandez, A., Miñano, J., & Nakamura, F. Y. (2019). Effects of Repeated Sprints With Changes of Direction on Youth Soccer Player's Performance: Impact of Initial Fitness Level. *Journal of Strength and Conditioning Research*, *33*(10), 2753–2759. https://doi.org/10.1519/JSC.0000000000002232
45. Wang, Y.-C., & Zhang, N. (2016). Effects of plyometric training on soccer players. *Experimental and Therapeutic Medicine*, *12*(2), 550–554. https://doi.org/10.3892/etm.2016.3419
46. Wong, D. P., Chan, G. S., & Smith, A. W. (2012). Repeated-Sprint and Change-of-Direction Abilities in Physically Active Individuals and Soccer Players. *Journal of Strength and Conditioning Research*, *26*(9), 2324–2330. https://doi.org/10.1519/JSC.0b013e31823daeab
47. Wong, D. P., Hjelde, G. H., Cheng, C.-F., & Ngo, J. K. (2015). Use of the RSA/RCOD Index to Identify Training Priority in Soccer Players. *Journal of Strength and Conditioning Research*, *29*(10), 2787–2793. https://doi.org/10.1519/JSC.0000000000000953
48. Young, W. B., James, R., & Montgomery, I. (2002). Is muscle power related to running speed with changes of direction? *Journal of Sports Medicine and Physical Fitness*, *42*(3), 282–288.

Corresponding author: DERRAA Yazid E-mail: derraa.yazid@univ-oeb.dz