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Effects of combined plyometric, speed and change of direction training on female soccer players on physical performance

Efectos del entrenamiento combinado de pliometría, velocidad y cambio de dirección en jugadoras de fútbol sobre el rendimiento físico

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Abstract. The objective of this study is to determine the influence of short-term combined plyometrics (PL), speed and change of direction (COD) training (6 weeks) within regular soccer practice on the jumping, speed and COD of female soccer players during the season. Twenty-three subjects were randomly assigned to PL+ speed + COD (COMB), or control group (CG). Subjects performed 2 sessions per week for 6 weeks. Before and after training contramovement jump (CMJ), contramovement jump with arms (CMJA), 10 metres (m) - 20m sprint and L-RUN tests were analysed. Within-group analysis showed substantial improvements in CMJ (effect size [ES] = 0.92), 20m sprint (ES: <0.001), L-run (ES: <0.001). Between-group analysis showed significant improvements in 20m sprint ($p \leq 0.001$). No significant improvements in CMJ ($p \leq 0.95$); CMJA ($p \leq 0.61$); 10m sprint ($p \leq 0.23$); L-Run ($p \leq 0.24$) in experimental groups in comparison to CG. The replacement of some low-intensity football drills with PLexercises combined with sprints and COD, during warm-up may be a possible option to optimise sprint performance.
Keywords: agility, vertical jump, speed, acceleration, soccer player, plyometrics, strength

Resumen. El objetivo de este estudio es determinar la influencia del entrenamiento combinado a corto plazo de pliometría (PL), velocidad y cambio de dirección (COD) dentro de la práctica regular del fútbol en los saltos, la velocidad y el cambio de dirección de jugadoras de fútbol durante la temporada. Veintitrés sujetos fueron asignados al azar a PL + velocidad + COD (COMB) o al grupo de control (GC). Los sujetos realizaron 2 sesiones por semana durante 6 semanas. Antes y después del entrenamiento, se analizaron los saltos con contramovimiento (CMJ), salto con contramovimiento con brazos (CMJA), sprints de 10 metros (m) - 20 metros y pruebas L-RUN. El análisis dentro del grupo mostró mejoras sustanciales en CMJ (tamaño del efecto [ES] = 0.92), sprint de 20 m (ES: <0.001), L-run (ES: <0.001). El análisis entre grupos mostró mejoras significativas en el sprint de 20 metros ($p \leq 0.001$). No se observaron mejoras significativas en CMJ ($p \leq 0.95$); CMJA ($p \leq 0.61$); sprint de 10 m ($p \leq 0.23$); L-Run ($p \leq 0.24$) en los grupos experimentales en comparación con el GC. La sustitución de algunos ejercicios de fútbol de baja intensidad con ejercicios de PL combinados con sprints y COD, durante el calentamiento, podría ser una opción posible para optimizar el rendimiento en sprint.
Palabras clave: agilidad, salto vertical, velocidad, aceleración, jugadora de fútbol, pliometría, fuerza.

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Introduction

Women's football has become more popular and more participated over the last decade. Due to the growth of women's football, women players are now more exposed to the physical demands of the game than ever before. Therefore, in order to develop better training programmes, it is necessary to have a better understanding of the changes in players' performance (Pardos-Mainer et al., 2021).

In today's football, players are required to be more and more athletic. This makes the physical and physiological demands more important in both young and senior soccer players. Within these demands we find actions that occur at moderate intensity (jogging), low-intensity (walking) and actions that occur at high intensity (i.e., sprinting, jumping, cutting, COD, or ball-shooting) (Sáez de Villarreal et al., 2015).If a match is analysed, it is observed that approximately one player performs 1,350 actions (every 4-6 seconds), of which high-intensity actions stand out, such as accelerations/decelerations, COD and jumps, since they are the most decisive actions in a match (Mohr et al., 2005). However, there is not as much information on women's matches, although some studies have found that female players perform between 1,350 and 1,650 change of pace per match (Datson et al., 2014) and that they perform accelerations every 14 seconds on average during a match (Mara et al., 2017). According to a study on the acceleration and deceleration profiles of elite female soccer players during competitive matches, players performed an average of 423 accelerations and 430 decelerations per match. The study found that the number of these efforts varied according to player position and the intensity of the match (Mara et al., 2017). Another study analysed that during a professional football match, players performed an average of 187 high-intensity runs and 23 sprints per match (Andersson et al., 2010). Despite this, there is still very little scientific literature on this topic, particularly concerning long-term performance trends and injury prevention in elite women's football (Datson et al., 2014).

Therefore, with the aim of improving performance, the improvement of these capacities, allowing the athlete to perform faster and more powerful movements, will be a key component in the soccer player's training (Beato et al., 2018; Mohr et al., 2003).

In both female and male soccer, speed, agility and power are essential skills. Therefore, players who demonstrate superiority over others in these qualities are frequently selected (Reilly & Williams, 2003). Thus, the training sessions should not only incorporate tasks at a technical-tactical level, but should also incorporate tasks that require the high intensity actions mentioned above that require high muscle strength levels, especially in lower body (Prieto et al., 2021; Suchomel et al., 2016). A myriad of training methods, including strength, PL, speed, COD, combined methods has been studied for researchers to develop sprint, vertical jump, and agility performance (Delecluse, 1997; Dos'Santos et al., 2017; Sáez de Villarreal et al., 2013; Sáez de Villarreal et al., 2009).

PL training methodology largely supported by scientific literature (Asadi et al., 2016; Sáez de Villarreal et al., 2012; Sáez de Villarreal et al., 2009; Sáez de Villarreal et al., 2010). In female soccer players, it has been shown that PL training provides a sufficient stimulus to improve explosive actions (Ozbar et al., 2014; Ramírez-Campillo et al., 2016; Rubley et al., 2011). PL includes jumping exercises using the stretch-shortening cycle (SSC) muscle action, this is a capacity of the Musculotendinous and nervous system that produces maximum force in the shortest amount of time during a rapid transition from an eccentric contraction to a concentric contraction of the muscle (Markovic et al., 2007; Markovic & Mikulic, 2010). It is important to mention that most of the lower-body movements in football are performed unilaterally. Thus, it is necessary to consider incorporating multidirectional unilateral plyometrics exercises in the soccer specific strength training interventions (Ramirez-Campillo et al., 2018).

In female soccer players, it has been shown that PL training provides a sufficient stimulus to improve explosive actions (Ozbar et al., 2014; Ramírez-Campillo et al., 2016; Rubley et al., 2011).

Efficiency when making a COD will depend on higher levels of motor control and balance, a minimum loss of speed and a short and maximal efforts with brief recovery periods (Hammami, Gaamouri, Aloui, et al., 2019; Sporis et al., 2010). It has previously been reported athletes who are habituated to performing different CODs and short shuttle runs become considerably more economical during those specific actions. A training program that includes repeated COD is necessary to develop agility (Beato et al., 2018; Coratella et al., 2016; Zamparo et al., 2015).

In order to maximize gains, using the Resisted method consists of performing the same exercises but adding an overload on the athlete (Rumpf et al., 2015). The overload during explosive actions causes greater neural activation, and a greater recruitment of fast contracting motor units (Faccioni, 2007). In this regard, the optimal resisted load for sprint training has not been established yet (Petrakos et al., 2016). Despite this, the authors recommend that the weight used not decrease more than 10% of the performance achieved without weight because it can produce important changes in the mechanics of the athlete (Lockie et al., 2003; Spinks et al., 2007).

The combination of different training methods seems to be an efficient way to improve neuromuscular performance during explosive actions such as jumps, COD or sprints (Newton & Kraemer, 1994; Sáez de Villarreal et al., 2013). The most studied combination has been Strength and PL, and it has been shown to be an effective method for improving the performance of these soccer motor skills (Adams et al., 1992; Fatouros et al., 2000). Therefore, training programs that combine strength and PL are recommended for soccer players. The time available for most non-elite or academy soccer teams for strength-training sessions during the in-season period is very limited. The search for time-efficient strategies that concurrently enhance performance in specific skills while preventing injuries is crucial (Prieto et al., 2021). Therefore, coaches and sport scientists have been making significant efforts to identify the best combinations between different modes of strength-power exercises and training strategies (Arede et al., 2019; Faude et al., 2013; Herrero et al., 2010).

In female, performance improvements have been obtained with combinations of PL+ strength training (Flória et al., 2019; Guadalupe-Grau et al., 2009) PL + balance (Bouteraa et al., 2020; Sanchez-Sixto et al., 2021), PL+ electrostimulation (Martinez-Lopez et al., 2012).In male soccer, performance improvements have been obtained with different combinations of PL + speed (Hammami, Gaamouri, Aloui, et al., 2019; Prieto et al., 2021; Sáez de Villarreal et al., 2015), PL+ strength +speed (Faude et al., 2013; Otero-Esquina et al., 2017; Rodriguez-Rosell et al., 2016, 2017). However, there are a lack of such studies in women's soccer, so it is not possible to extrapolate these results and it is necessary to analyse the combinations of different training methods in women's soccer.

Considering the above considerations, the aim of this study was to examine the effects of a PL program supplemented with sprint and COD training program during season in specific explosive actions (speed, COD and jump) among female soccer players. It was hypothesized that the combination of soccer technical exercises and the proposed combined specific training program over a 6-week period would improve players' explosive actions (sprint, COD and jump) to a greater extent than the CG.

Methods

Experimental Approach to the Problem

This study was designed to investigate whether significant increases in lower-body muscle power could be obtained in female soccer players if the first part of their regular training program (i.e., 20 min of tactical and technical drills) was replaced by 6 weeks of combined training (vertical, horizontal, and lateral jumping, sprints, and COD exercises).

The effects of 6 weeks of combined training were compared in combined training groups vs a CG. None of the groups undertook any other training other than the standard soccer training regimen. All subjects were evaluated before (Pre) and after 6 weeks of training (Post) using a battery of tests performed in the following order: (a) CMJ; (b) CMJA; (c) 10-20 m all-out running sprints; and (d) L-RUN change of direction test. The intervention was carried out during the final period of the season (April–May). During the week preceding this study, one preliminary familiarization session was undertaken to ensure a proper execution technique in both 10.20 m sprint, L-RUN, CMJ and CMJA exercises.

The duration of 6 weeks was chosen based on previous research indicating that this time frame is sufficient to elicit notable improvements in muscle power and performance (Markovic, 2017; Michailidis et al., 2013).For instance, Michailidis et al. (2013) found significant gains in sprint performance and jump height in youth soccer players following a 6-week plyometric training program. Similarly, Ramírez-Campillo et al. (2018) demonstrated that a 6-week plyometric regimen led to substantial enhancements in explosive actions and agility in soccer players.

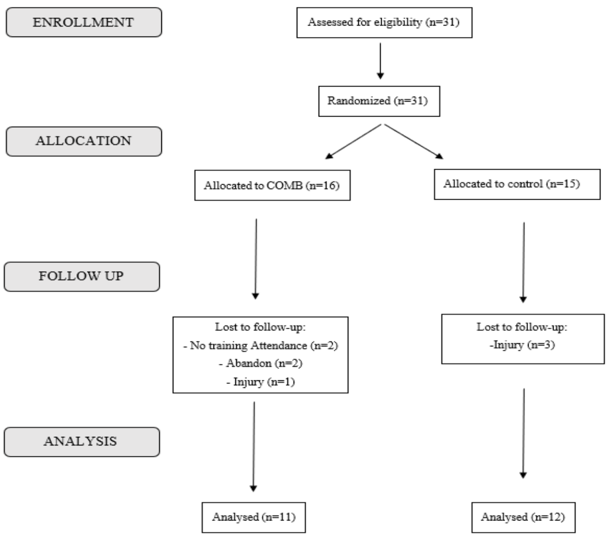

Figure 1. Consort diagram

Subjects

31 trained female soccer players around 21.6 ± 3.42 years volunteered for this study. The subjects were recruited from the same Spanish and were competing in national division. After the initial evaluation, the 31 soccer players in each cohort were randomized divided into two groups one team whose players participated in plyometric combined with speed and COD training (COMB1, n=11) and the other team whose players were enrolled in CG (n=12). Only those players who participated in at least 70% of all training sessions (23 players) were included into statistical analyses. Because of injury, illness, or abandon the study 8 players (5 COMB and 3 CG) missed too many training sessions or were absent from the post testing session (Figure 1). Player's characteristics are displayed in Table 1. Subjects were soccer trained for more than 11.2 ± 4.09 (COMB), and 11.8 ± 2.73 (CG) years. Subjects had experience in weight training, they did not perform strength training as part of their normal training routine. To be included in the study, they were injury free for at least 3 months before participating in the study. Coach and players were informed about the different tests procedures performed during the study. The study was conducted according to the Declaration of Helsinki and conforms to the Code of Ethics of the World Medical Association. The study was approved by the Research Ethics Committee of Pablo de Olavide University. Players signed informed consent for all players under the age of 18 involved in this investigation were obtained, as well as participant's assent.

Table 1.
Characteristics of the groups (mean ± SD)

Group	Age (y)	Height (cm)	Body weight (kg)	Soccer experience (y)
COMB	23.4±3.96	163±3.41	57.3±3.8	11.2±4.09
Control	19.9±1.73	163±7.75	60.3±7.55	11.8±2.73

Testing procedure

Anthropometric measurements were taken before the physical testing. The standing height (centimetres) and body mass (kilograms) were measured. Neuromuscular performance was assessed before and after training using a battery of tests performed in two sessions, the first one for vertical jump and the second one for velocity and COD as described below. The tests were performed after 48 hours of rest from the last training or competition session. Testing sessions were performed at the same venue and time of day (± 0.5 hour). Strong verbal encouragement was provided during all tests to motivate subjects to give a maximal effort.

Vertical Jump

A warm-up was completed before the test, consisted of 5 min of running, 2 sets of 10 repetitions of submaximal squat without extra load, 1 set of 10 submaximal CMJ and 1 set of 10 submaximal CMJA. Thereafter the athletes performed the CMJ. From an upright position, participants performed a rapid downward movement to a knee angle of ~90º and simultaneously beginning to push-off. For the CMJA, from an upright position, participants performed a rapid downward movement to a knee angle of ~90º and simultaneously beginning to push-off, with arm-swing. The height of the jump was measured with a jump mat (Chronojump Boscosystems). Each player performed three maximal jumps, with an inter-trial rest of 45-second. The highest jump was used in subsequent analyses.

10-20 Meter Sprint Performance test

The warm-up protocol consisted of 5 min of running and 2 sets of 4 progressively faster 10-20-m running accelerations, was followed in the pre-test and post-test. Individuals started from a standing position, with the front foot 0.2 m from the first photocell beam. Subjects were required to give an all-out maximal effort in each sprint and the best of the three trials was kept for subsequent analysis. Subjects ran 10-20 m recorded by paired photocells (Microgate, Bolzano, Italy). Three trials were separated by 3 minutes of recovery.

L-RUN test

The warm-up protocol consisted of three submaximal trials. Three cones were placed 5 m apart in an "L" shape. The front foot was placed 0.2 m before the first timing gate at the beginning of the test. Players started in the standing position and were required to run forward 5 m, then turn to their left, run forward 5m, then turn 180°, and follow the same course to return to the start/finish line (Webb & Lander, 1983). The test was completed when the participant crossed the start/finish line. The cones used were 0.5 m in height. Players were instructed to run as quickly as possible along the "L". Times were registered through photocells (Microgate, Bolzano, Italy). Three trials, separated by 3 min rest, were completed, and the best performance trial was used for further analysis.

Strength Training Program

Training groups trained twice a week on Tuesday and Thursday, for a period of 6 weeks. Intervention training sessions lasted ~20 minutes. Table 2 describes the training program. In all sessions, warm-up consisted of 5 minutes of jogging. The training program for the COMB groups was divided into two blocks of 3 weeks, the first three weeks performing all exercises with body weight and the following three weeks with ~9% of body weight of the group average added to all exercises by a weight vest. The PL work was divided into two days: the first day of the week jumps were performed with both legs and the second day jumps were performed with one leg. The Comb group performed 75 jumps and 9 sprints with COD. All the series finished with a finish in mini goals.

Table 2.
Training program

PROGRAM	BLOCK 1		BLOCK 2	
	DAY 1 Sessions 1-3-5	DAY 2 Sessions 2-4-6	DAY 1 Sessions 7-9-11	DAY 2 Sessions 8-10-12
Combined training				
Box jump	5X3	----	5X3	---
Landing jump	---	5X3	---	---
Drop jump	---	---	---	5X3
Horizontal jump 2 legs	10X3	---	10X3	---
Horizontal jump 1 leg	---	10X3	---	10X3
Lateral jump 2 legs	10X3	---	10X3	---
Lateral jump 1 leg	---	10X3	---	10X3
5 meters sprint	1X3	1X3	1X3	1X3
10 meters sprint	1X3	1X3	1X3	1X3
20 meters sprint	1X3	1X3	1X3	1X3
45º COD	1X3	1X3	1X3	1X3
90º COD	1X3	1X3	1X3	1X3
180º COD	1X3	1X3	1X3	1X3

Statistical Analyses

Descriptive statistics (mean ± Standard Deviation (SD)) for the different variables were calculated. Independent samples T-tests were executed to analyse differences between the two experimental groups for anthropometrics (height, weight). An analysis of variance (ANOVA) with repeated measures (Group × Time) was used to analyse performance variables after training (pre and post intervention). When the ANOVA revealed significant main effects or interactions, a Bonferroni post hoc test was applied to test the discrimination between means. The statistical significance level was set at $p<0.05$. Effect sizes were interpreted using previously outlined ranges (<0.2 = trivial; 0.2-0.6 = small, 0.6-1.2 = moderate, 1.2-2.0 = large, 2.0-4.0 = very large, >4.0 = extremely large) (Hopkins et al., 2009). The smallest effect was classified as 0.2 of the between-subject standard deviation (Hopkins et al., 2009).

Results

No significant differences in the anthropometric variables measured (body weight and height) were observed in the pre-test between the experimental and CG.

Vertical Jump

Statistically significant increases ($p \leq 0.012$) occurred in the COMB group in CMJ (centimetres) (COMB [2,3 cm, ES = 0.92]). No statistically significant increases ($p \leq 0.08$) occurred in CMJA (centimetres) (COMB [1.4 cm, ES = 0.59]). No Significant differences ($p \leq 0.95$); ($p \leq 0.61$) in CMJ and CMJA respectively were observed after training in the magnitude of the increase between the experimental group and CG
(Table 3).

Sprint Time

Statistically significant increases ($p \leq 0.001$) occurred in the COMB group in 20m test (Seconds) (COMB [0.13 sec, ES = 1.99]). No Statistically significant increases ($p \leq 0.45$) occurred in the COMB group in 10m test (Seconds) (COMB1 [0.01 sec, ES = 0.24]). Significant differences ($p \leq 0.001$) in 20Mmtest were observed after training in the magnitude of the increase between the experimental group and CG. No Significant differences ($p \leq 0.23$) in 10m test were observed after training in the magnitude of the increase between the experimental group and CG (Table 3).

L-Run test

Statistically significant increases ($p \leq 0.001$) occurred in the COMB group in L-Run test (Seconds) (COMB [0.61 sec, ES = 1.41]). No Significant differences ($p \leq 0.24$) in L-run test were observed after training in the magnitude of the increase between the experimental group and CG (Table 3).

Table 3.
Within-group analysis: baseline and follow-up scores, effect sizes, confidence limits, and P value.

Group	Test	Baseline ± SD	Follow-up ± SD	Effect size and CI	P	Effect description
COMB group	CMJA	31.8±3.13	33.2±3.87	0.59 (-0.07 to 1.22)	0.08	Small
	CMJ	27.6±2.76	29.9±4.03*	0.924 (0.2 to 1.62)	0.012	Moderate
	10M Sprint	1.94±0.06	1.93±0.08	0.24 (-0.37 to 0.83)	0.448	Small
	20M Sprint	3.53±0.06	3.4±0.11***	1.99 (0.93 to 3.01)	<0.001	Large
	L-Run	8.73±0.33	8.12±0.36***	1.41 (0.55 to 2.25)	<0.001	Large
Control group	CMJA	28.8±3.63	30.7±3.81***	1.31 (0.51 to 2.08)	<0.001	Large
	CMJ	26.2±4.16	28.5±4.34***	1.56 (0.69 to 2.41)	<0.001	Large
	10M Sprint	1.95±0.1	1.97±0.08	-0.28 (-0.85 to 0.31)	0.360	Small

	20M Sprint	3.41±0.1	3.44±0.13	-0.46 (-1.05 to 0.15)	0.139	Small
	L-Run	8.96±0.19	8.52±0.19***	1.91 (0.93 to 2.86)	<0.001	Large

*p< .05, **p< .01, ***p< .001, compared with follow-up values. Abbreviations: Contramovement Jump with arms (CMJA); Contramovement Jump (CMJ).

Discussion

The aim of this study was to examine the effect of substituting some regular in-season training with 6 weeks of biweekly combined PL with short sprints and COD training in female soccer players during the season to maximize physical performance (i.e., jumping, sprint and COD). In this context, we accept our hypothesis in that combined PL method with speed and change of direction in-season would improve 20m sprint performance in a group of female soccer players compared with CG. The significant improvements are consistent with the principles of plyometric training and its impact on neuromuscular adaptations. According to the stretch-shortening cycle theory, plyometric exercises enhance muscle power by improving the efficiency of the musculotendinous system's ability to store and release elastic energy (Asadi et al., 2016). However, we found no significant changes in jump, COD and 10m sprint performance tests. When comparing changes between the COMB group and the CG. Thus, the study hypothesis for these variables was not confirmed, thus accepting the alternative hypothesis.

Our results revealed that, compared with pre-training, the COMB group significantly increased speed performance by 0.13s (ES: 1.99; p<0.001) for 20m sprint and even the increase in 10m sprint was not significant, the tendency was positive 0.01s, (ES: 0.24; p<0.45) for 10m sprint, compared with CG were the they performance decrease in both tests 10m (ES: -0.28; p<0.36) and 20m (ES:-0.46; p<0.139). The significant decrease in sprint times aligns with the overload principle, which posits that adding resistance to speed training can enhance neural activation and muscle recruitment, leading to improved sprint performance (Faccioni, 2007).

These results tend to support most of the previous published studies performed examining these types of training interventions with soccer players (Marques et al., 2013; Otero-Esquina et al., 2017; Sáez de Villarreal et al., 2015). It has been reported sprinting is highly dependent on the ability to generate relative peak force, rate of force development (RFD) and peak power output capability muscular power in the extension of the ankle, knee, and hip joints (Haff & Nimphius, 2012). The application of resisted methods causes adaptations such as: increased RFD and increased muscle strength (Alcaraz et al., 2014; Harrison & Bourke, 2009; Lockie et al., 2012; Spinks et al., 2007). It has also been suggested that it can lead to increased neural activation with increasing exercise load (Cissik, 2004), increased recruitment of fast twitch motor units (Upton, 2011) and improved intermuscular coordination (Faccioni, 2007; Young, 2006). Beyond physiological adaptations, a positive transfer to kinematics (contact time, flight time, stride amplitude and frequency, etc.) can also be found, resulting in increased performance (Alcaraz et al., 2014; Cross et al., 2014; Murphy et al., 2003).

The success of a vertical jump is determined by the velocity at take-off, and reductions of time between eccentric and concentric movement during PL training allow an athlete to become faster and more powerful through improvements in muscle, tendon, and nerve function (Asadi et al., 2016; Behrens et al., 2016). The improvements in COD performance observed in the L-Run test suggest enhanced motor control and balance, likely due to the repetitive nature of COD drills included in the training program. This aligns with the agility training theories, which emphasize the importance of high-intensity, multidirectional movements for improving specific athletic skills (Beato et al., 2018). The success on improving jump height during PL training are attributable to neural adaptations rather than morphologic changes (Sáez de Villarreal et al., 2008). Nevertheless, neither muscle mass nor neuromuscular variables were assessed in the present study. Further studies focusing on neuromuscular factors are required in order to corroborate this for soccer players. Adaptations to training are likely to be neural because these predominate in the early stages of strength and power training (Billot et al., 2010) and have been shown to be the main adaptation to PL exercise (Diallo et al., 2001; Michailidis et al., 2013). Neural adaptations are associated with improvement in maximal voluntary contraction, more synergistic muscle activation and less antagonistic muscle activation (i.e., intermuscular coordination), greater motor unit recruitment (i.e., intramuscular coordination) and stretch reflex excitability (Markovic & Mikulic, 2010). Furthermore, Kobal et al. (Kobal et al., 2017) reported that the use of additional load during executed jumps allowed players to apply greater force against the ground in the direction of intended movement (vertical or horizontal axes) on a longer period of time. This mechanical adjustment generates higher impulses (possibly additional overload) during jumps (Cronin et al., 2014), thus producing a greater adaptation of jumping ability in the loaded group (Kobal et al., 2017).

Despite, in this study even significant improvements were observed in vertical jump CMJ (ES: 0.92; p<0.012) and not statistically significant but with a positive tendency (ES: 0.59; p<0.08) between baseline and post-test in the combined group. When the results were analysed with the CG, no significant different were found. Therefore, it can be concluded that the regular soccer training sessions were enough to improve the vertical jump ability in both groups. The lack of improvement of the COMB group with respect to the control group could be due to the fact that the training applied has not produced a sufficient stimulus, when different frequencies are compared it has been observed that higher training frequencies obtain better results than lower frequencies, 3 days compared to 1 or 2 days and 2 days compared to 1 day (Graves et al., 1988; Häkkinen & Kallinen, 1994; Turpela et al., 2017). Being a group of semi-professional level players, the effects of a higher training frequency should be studied, since it has been seen that elite athletes in other sports, for example elite weight lifters, can benefit from using training frequencies between 8 and 12 sessions per week (Häkkinen et al., 1988; Zatsiorsky & Kraemer, 1995).

The combined methodology has been applied in several recent investigations performed in soccer players where incorporate the use of loaded and unloaded combined PL with sprints or COD or both (Beato et al., 2018; Hammami et al., 2016, 2020; Michailidis et al., 2019; Prieto et al., 2021; Sáez de Villarreal et al., 2015). However, Our data are in disagreement with investigations in soccer players which have described improved jump performance following combined PL with strength sprints and COD training (Franco-Márquez et al., 2015; Rodríguez-Rosell et al., 2017). Further studies are needed to corroborate if the combination of methods is more beneficial for the vertical jump than the soccer practice alone in semi-professional women players.

To understand the adaptations that underlie after the training program to COD performance it has to be understood that the COD ability refers to a replanned movement where no immediate reaction to a stimulus is required. It is affected by the individual's strength, power, and speed (Sheppard & Young, 2006). The fastest performance in COD speed test is mainly described by higher contribution of isometric and eccentric strength capacities, as well as higher braking and propulsive forces, lower contact time, time spent braking and propulsive (Spiteri et al., 2015). However, given the multiple-component of the COD movements , the implement of exercise tasks that produced eccentric overload (de Hoyo et al., 2015), unilateral training (Buchheit et al., 2010), multidirectional movements (backward and/or forward and lateral directions) (Los Arcos et al., 2014), and angle- or movement-specific tasks (Milanović et al., 2013), may be more beneficial than implemented and one in isolation.

Moreover, some studies following these guidelines examined the effects of combined training on COD and observed significant improvements after training (Aloui et al., 2021; Hammami et al., 2020; Hammami, Gaamouri, Shephard, et al., 2019; Makhlouf et al., 2018; Sáez de Villarreal et al., 2015). Nevertheless, in this study, No significant improvements were observed in COD test between groups what is in accordance with the findings obtained in several recent investigations (Arede et al., 2019; Beato et al., 2018; Michailidis et al., 2019). In addition, dissimilarities in acute program variables (duration, intensity, and frequency) and methodology (period and duration of studies and age, gender, and competitive level of players) could contribute to discrepancies between study results. The protocols proposed in the current study used a training frequency of 2 sessions a week that seems not sufficient stimulus to improve power parameters in female soccer players.

In summary, this data clearly demonstrated that adding combined plyometric and sprint training in previously trained female soccer players seems to be a good stimulus for improving speed in 10m and 20m. Although, improvements in jumping and agility ability could not be demonstrated, more studies are needs to obtain stronger conclusions.

This study has some limitations. The first limitation is associated with the small sample enrolled. A bigger sample could have offered a better view about the effect obtained by the three protocols. A justification of such sample size is associated with the specificity of the population enrolled and with the restrictive access to soccer players in season. The second limitation is gender related. We cannot speculate that our results can be extended to other specific populations (e.g., elite male players). The third limitation is the time of the intervention, longer training periods may produce greater gains than the control group.

Conclusion

In conclusion, the replacement of some low-intensity soccer drills with PL combined with sprints and COD exercises during the warm-up may is one potential option to optimize Sprint performance during the in-season soccer training. However, no improvements were observed in jumping and COD ability when results were compared with CG. Future studies may wish to compare these results to other genders, age groups, and competitive level of players. These improvements in speed performance might aid performance in competition and may reduce injury risk (Arnason et al., 2004).

Practical Applications

This study showed biweekly in-season loaded PL and short sprints with COD training enhances Sprint performance and even didn't improve jumping and COD ability in female soccer players, this intervention can be implemented due to possible beneficial effects of the combination of methods in the same session discussed above. Therefore, strength and conditioning coaches should incorporate PL and short sprints with COD training into in-season soccer training to enhance players performance.

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