

Effects of combined plyometric, strength, speed and change of direction training on youth male soccer players on physical performance: A randomised controlled trial

Efectos del entrenamiento combinado de pliometría, fuerza, velocidad y cambio de dirección en el rendimiento físico de jugadores jóvenes de fútbol masculino: Un ensayo controlado aleatorio

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Abstract. The objective of this study is to determine the influence of short-term plyometric or combined training (6 weeks) within regular soccer practice on the jumping and change of direction actions of young soccer players during the season. Thirty players were randomly assigned to three groups: plyometrics (PL), plyometrics + speed + Change of direction (COD) (COMB1), or PL + speed + COD + strength (COMB2). All players trained soccer 3 times per week and the experimental groups change the typical tactical warm up with a proposed PL or combined training program for 20 minutes (2 days per weeks) for 6 weeks. Before, after training, free-arm countermovement jump (CMJA) and L-RUN tests were analysed. Within-group analysis showed substantial improvements in CMJA (ES: 0.73;1.27;1.16) in COMB1, COMB2 and PL while COMB1 and COMB2 also showed substantial enhancements in COD tests (ES: 3.75; 2.15). Between-group analysis showed substantially greater improvements in COD variables ($p \leq 0.001$; $p \leq 0.001$) in experimental groups in comparison to PL. Finally, COMB1 and COMB2 showed no significant enhancements in L-Run ($p \leq 0.234$). The replacement of some low-intensity football drills with PL combined with strength, sprints and COD. during warm-up may be a possible option to optimise jumping and change of direction ability during in-season football training.

Keywords: agility, vertical jump, speed, acceleration, soccer player, plyometrics, strength

Resumen. El objetivo de este estudio es determinar la influencia del entrenamiento pliométrico a corto plazo o del entrenamiento combinado (6 semanas) dentro de la práctica regular de fútbol en los saltos y las acciones de cambio de dirección de jóvenes jugadores de fútbol durante la temporada. Treinta jugadores fueron asignados al azar a tres grupos: pliometría (PL), pliometría + velocidad + cambio de dirección (COD) (COMB1) o PL + velocidad + COD + fuerza (COMB2). Todos los jugadores entrenaron 3 veces por semana y los grupos experimentales cambiaron el calentamiento táctico típico por un programa propuesto de pliometría o entrenamiento combinado durante 20 minutos (2 días por semana) durante 6 semanas. Antes y después del entrenamiento, se analizaron los saltos con contramovimiento con brazos libres (CMJA) y las pruebas L-RUN. El análisis dentro de los grupos mostró mejoras significativas en CMJA (ES: 0.73;1.27;1.16) en COMB1, COMB2 y PL, mientras que COMB1 y COMB2 también mostraron mejoras significativas en las pruebas COD (ES: 3.75; 2.15). El análisis entre grupos mostró mejoras significativas mayores en las variables de COD ($p \leq 0.001$; $p \leq 0.001$) en los grupos experimentales en comparación con PL. Finalmente, COMB1 y COMB2 no mostraron mejoras significativas en L-Run ($p \leq 0.234$). La sustitución de algunos ejercicios de fútbol de baja intensidad con pliometría combinada con fuerza, sprints y COD durante el calentamiento podría ser una opción posible para optimizar la capacidad de salto y cambio de dirección durante el entrenamiento de fútbol en temporada.

Palabras clave: agilidad, salto vertical, velocidad, aceleración, jugador de fútbol, pliometría, fuerza.

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Introduction

Due to the fact that soccer is the most popular sport in the world, many studies have been carried out to understand what the most important skills are required by soccer players (Datson et al., 2014; Hoff, 2005; Stølen et al., 2005). Despite this, there is still very little scientific literature on this topic. Because of this, many soccer players learn their soccer skills as a result of individual training experiences rather than academic research-based instruction (López-Segovia et al., 2011; Marques et al., 2013).

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, Suarez-Arrones, Requena, Haff, & Ferrete, 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). 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 youth soccer, speed, agility and power are essential skills. Therefore, players who demonstrate superiority over others in these qualities are frequently selected (Reilly & Williams, 2003). To achieve high performance levels in these physical qualities, training must start at an early age during long-term athlete development. A structured approach to the training of young athletes with one of the goals to maximize sporting talent by increasing the likelihood of developing a gifted child into a world-class athlete (Lloyd et al., 2015). 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,

especialmente en la parte inferior del cuerpo para poder realizar acciones de alta intensidad de manera más eficiente y con mejores resultados (Prieto et al., 2021; Suchomel et al., 2016). Se ha demostrado que la fuerza y la velocidad son cualidades físicas clave para los deportes de equipo en los que la potencia es una prioridad, como el fútbol (Gissis et al., 2006; Reilly et al., 2000). El término "potencia" se refiere a la capacidad de un sistema neuromuscular para generar la máxima cantidad de fuerza en el menor tiempo posible. Es una medida de la velocidad a la que se puede aplicar la fuerza. En el contexto del rendimiento atlético, la potencia es crucial en actividades que requieren movimientos explosivos, como saltos, sprints, o lanzamientos. Mejorar la potencia puede resultar en un rendimiento atlético mejorado en disciplinas que demandan velocidad y fuerza explosiva. La potencia puede medirse y evaluarse a través de varias pruebas y métodos, como el salto vertical (e.g., CMJ) y el sprint de corta distancia (Kraemer & Newton, 2000). El CMJ sirve como una medida confiable para evaluar la potencia explosiva y la fuerza de la parte inferior del cuerpo (Bosco et al., 1983). Estas evaluaciones ayudan a los entrenadores y atletas a comprender el nivel de capacidad explosiva y a diseñar programas de entrenamiento específicos para mejorarla.

Una gran variedad de métodos de entrenamiento, incluyendo fuerza, PL, velocidad, COD, métodos combinados ha sido estudiado por investigadores para desarrollar el sprint, el salto vertical, y el rendimiento de la agilidad (Delecluse, 1997; Dos'Santos et al., 2017; Sáez de Villarreal et al., 2013; Sáez de Villarreal et al., 2009).

La metodología de entrenamiento pliométrico está ampliamente respaldada por la literatura científica (Asadi et al., 2016; Sáez de Villarreal et al., 2012; Sáez de Villarreal et al., 2009; Sáez de Villarreal et al., 2010). En jóvenes jugadores de fútbol, se ha demostrado que el PL proporciona un estímulo suficiente para mejorar las acciones explosivas (Chelly et al., 2010; Diallo et al., 2001; Kotzamanidis et al., 2005; Meylan & Malatesta, 2009; Wong et al., 2010). El PL incluye ejercicios de saltos que utilizan el ciclo de estiramiento-acortamiento (SSC) de la acción muscular, lo que es una capacidad del sistema musculotendinoso y nervioso que produce la máxima fuerza en el menor tiempo durante una rápida transición de una contracción excéntrica a una contracción concéntrica del músculo (Markovic et al., 2007; Markovic & Mikulic, 2010). Es importante mencionar que la mayoría de los movimientos de la parte inferior del cuerpo en el fútbol se realizan unilateralmente. Por lo tanto, es necesario considerar incorporar ejercicios de PL unilaterales multidireccionales en los programas de entrenamiento de fuerza específicos para el fútbol (Ramirez-Campillo et al., 2018).

La eficiencia al realizar un cambio de dirección dependerá de niveles más altos de control motor y equilibrio, una mínima pérdida de velocidad y un corto tiempo de recuperación con esfuerzos máximos (Hammami, Gaamouri, Aloui, et al., 2019; Sporis et al., 2010). Se ha reportado previamente que los atletas acostumbrados a realizar diferentes CODs y carreras de relevos cortas se vuelven considerablemente más económicos durante esas acciones específicas. Un programa de entrenamiento que incluya repeticiones de COD es necesario para desarrollar la agilidad (Beato et al., 2018; Coratella et al., 2016; Zamparo et al., 2015).

Para maximizar los beneficios, el método de resistencia consiste en realizar los mismos ejercicios pero añadiendo una sobrecarga al atleta (Rumpf et al., 2015). La sobrecarga durante acciones explosivas causa una mayor activación neuronal y un mayor reclutamiento de unidades motoras rápidas (Faccioni, 2007). En este aspecto, la carga de resistencia óptima para el entrenamiento de sprint aún no se ha establecido (Petraikos et al., 2016). A pesar de esto, los autores recomiendan que el peso utilizado no disminuya más del 10% del rendimiento logrado sin peso, ya que puede producir cambios importantes en la mecánica del atleta (Lockie et al., 2003; Spinks et al., 2007).

La combinación de diferentes métodos de entrenamiento parece ser una manera eficiente de mejorar el rendimiento neuromuscular durante acciones explosivas como saltos, COD o sprints (Newton & Kraemer, 1994; Sáez de Villarreal et al., 2013). La combinación más estudiada ha sido fuerza y PL, y se ha demostrado que es un método efectivo para mejorar el rendimiento de estas habilidades motoras (Adams et al., 1992; Fatouros et al., 2000). Por lo tanto, los programas de entrenamiento que combinan fuerza y PL son recomendados para los jugadores de fútbol. El tiempo disponible para la mayoría de los equipos de fútbol no élite o de academia durante el periodo de entrenamiento en temporada es muy limitado. La búsqueda de estrategias de tiempo eficiente que mejoren concurrentemente el rendimiento en habilidades específicas mientras se previenen lesiones es crucial (Prieto et al., 2021). Por lo tanto, los entrenadores y científicos del deporte han estado haciendo esfuerzos significativos para identificar las mejores combinaciones entre diferentes modos de ejercicios de fuerza-potencia y programas de entrenamiento (Arede et al., 2019; Faude et al., 2013; Herrero et al., 2010). En jóvenes jugadores de fútbol, los mejoramientos de rendimiento se han obtenido con diferentes combinaciones de PL+ entrenamiento de fuerza (Arabatzi et al., 2010; Sáez de Villarreal, Suarez-Arrones, Requena, Haff, & Ramos Veliz, 2015; Sanchez-Sixto et al., 2021), PL + Velocidad (Hammami, Gaamouri, Aloui, et al., 2019; Prieto et al., 2021; Sáez de Villarreal, Suarez-Arrones, Requena, Haff, & Ferrer, 2015), PL+ fuerza+ velocidad (Faude et al., 2013; Otero-Esquina et al., 2017; Rodriguez-Rosell et al., 2016, 2017). Considerando lo anterior, el objetivo de este estudio fue examinar los efectos de un programa de PL ya sea suplementado con un sprint y COD o suplementado con fuerza, sprint y COD durante la temporada en acciones explosivas (COD y salto) entre jugadores de fútbol de temprana pubertad. Se hipotetizó que la combinación de ejercicios técnicos y el programa de entrenamiento específico durante un periodo de 6 semanas mejoraría las acciones explosivas (COD y salto) a un mayor nivel que el entrenamiento de PL solo.

Methods

Experimental Approach to the Problem

This study was designed to investigate whether signif-

icant increases in lower-body muscle power could be obtained in young male 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, strength, sprints and COD exercises depending on the group) or PL alone.

The effects of 6 weeks of combined training were compared in three different groups a PL group and two combined training groups. 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) CMJA and (b) 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 L-RUN and CMJA exercises.

Subjects

The subjects were recruited from the same academy affiliated with a semi-professional team in Spanish third division and were competing in the U11 (n = 12), U11 (n = 12), or U12 (n = 12) divisional age groups. After the initial evaluation, the 36 soccer players in each cohort were randomly divided into three groups: those who participated in plyometric training (PL, n=10), PL combined with speed and COD training (COMB1, n=11) and PL combined with strength, speed, and COD training (COMB2, n=9). Only those players who participated in at least 70% of all training sessions (30 players) were included into statistical analyses. Because of injury or illness not caused by the intervention, 6 players (2 PL, 1 COMB1 and 3 COMB2) 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 4 (PL), 6 (COMB1), and 6 (COMB2) years. Subjects had no experience in weight training, and 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 6 months before participating in the study. Coach and parents were informed about the different test 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. Parental or guardian signed informed consent for all players under the age of 18 involved in this investigation were obtained, as well as participant's assent.

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 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.

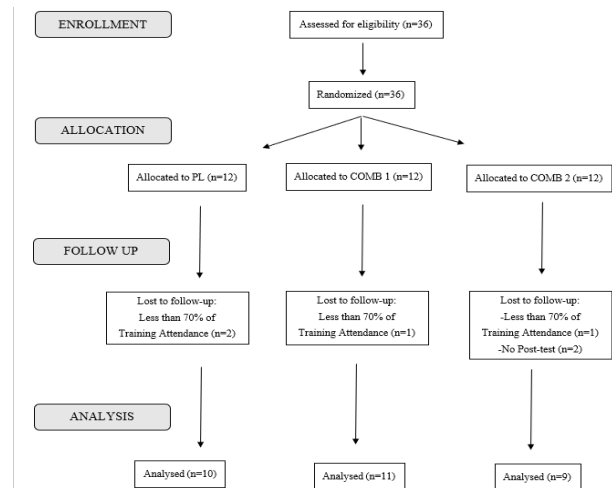


Figure 1. Consort diagram

Table 1.

Characteristics of the groups (mean \pm SD).

Group	Age (y)	Height (cm)	Body weight (kg)	Soccer experience (y)
PL	11.3 \pm 0.483	148 \pm 8.64	40 \pm 8.35	3.7 \pm 1.7
COMB1	10.8 \pm 0.405	146 \pm 4.43	39.4 \pm 5.23	5.91 \pm 0.944
COMB2	10.6 \pm 0.527	148 \pm 7.58	38.3 \pm 4.12	5.56 \pm 1.13

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 and 2 set of 10 submaximal CMJA. Thereafter the athletes performed the CMJA. From an upright position, participants performed a rapid downward movement to a knee angle of $\sim 90^\circ$ 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.

L-RUN test

The warm-up protocol consisted of 5 min of running and 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 three 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 ~12% of body weight of the group average added to all exercises by a weight vest. The workload of the three different training programs was divided proportionally. Effort perception was analysed at the end of each training intervention using the Borg Rating of Perceived Scale. 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. Regarding the amount of the load, it was divided as follows: the PL group performed a total of 150 jumps per session. The COMB1 group performed 75 jumps and 9 sprints with COD. The COMB2 group performed 50 jumps and 6 sprints with COD. All groups finished the series 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
Plyometric training				
Box jump	5X6	---	5X6	---
Landing jump	---	5X6	---	---
Drop jump	---	---	---	5X6
Horizontal jump 2 legs	10X6	---	10X6	---
Horizontal jump 1 leg	---	10X6	---	10X6
Lateral jump 2 legs	10X6	---	10X6	---
Lateral jump 1 leg	---	10X6	---	10X6
Combined training 1				
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
45° COD	1X3	1X3	1X3	1X3
90° COD	1X3	1X3	1X3	1X3
180° COD	1X3	1X3	1X3	1X3
Combined training 2				
Box jump	5X2	---	5X2	---
Landing jump	---	5X2	---	---
Drop jump	---	---	---	5X2
Horizontal jump 2 legs	10X2	---	10X2	---
Horizontal jump 1 leg	---	10X2	---	10X2
Lateral jump 2 legs	10X2	---	10X2	---
Lateral jump 1 leg	---	10X2	---	10X2
5 meters sprint	1X2	1X2	1X2	1X2
10 meters sprint	1X2	1X2	1X2	1X2
20 meters sprint	1X2	1X2	1X2	1X2
45° COD	1X2	1X2	1X2	1X2
90° COD	1X2	1X2	1X2	1X2
180° COD	1X2	1X2	1X2	1X2
SQUAT	10X2	10X2	10X2	10X2
LUNGE	10X2	10X2	10X2	10X2
LATERAL LUNGE	10X2	10X2	10X2	10X2

Statistical Analyses

Descriptive statistics (mean \pm 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 \times 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 combined groups and PL group.

Vertical Jump

Statistically significant increases ($p \leq 0.04$) occurred in the PL group in CMJA (centimetres) (PL [1.7 cm, ES =

0.732]). Statistically significant increases ($p \leq 0.002$) occurred in the COMB1 group in CMJA (centimetres) (COMB1 [2 cm, ES = 1.27]). Statistically significant increases ($p \leq 0.008$) occurred in the COMB2 group in CMJA (centimetres) (COMB2 [2.1 cm, ES = 1.16]) (Table 3). No Significant differences ($p \leq 0.847$); ($p \leq 0.749$); ($p \leq 0.861$) in CMJA test were observed after training in the magnitude of the increase between COMB 1, COMB 2 groups and PL group (Table 4).

Table 3.

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

Group	Test	Baseline \pm SD	Follow-up \pm SD	Effect size and CI	P	Effect description
PL group	CMJA	30.7 \pm 5.44	32.4 \pm 5.08	0.732 (0.013 to 1.42)	0.046	Moderate
	L-Run	9.79 \pm 0.598	9.76 \pm 0.611	0.113 (-0.512 to 0.732)	0.728	Trivial
COMB1 group	CMJA	28.9 \pm 4.22	30.9 \pm 3.91	1.27 (0.446 to 2.06)	0.002	Large
	L-Run	9.79 \pm 0.556	8.51 \pm 0.61	3.75 (2.02 to 5.46)	<0.001	Large
COMB2 group	CMJA	29.1 \pm 3.81	31.2 \pm 4.73	1.16 (0.281 to 2.00)	0.008	Moderate
	L-Run	9.97 \pm 0.477	8.83 \pm 0.377	2.15 (0.913 to 3.36)	<0.001	Large

L-Run test

No Statistically significant increases ($p \leq 0.728$) occurred in the PL group in L-Run test (Seconds) (PL [0.03 sec, ES = 0.113]). Statistically significant increases ($p \leq 0.001$) occurred in the COMB1 group in L-Run test (Seconds) (COMB1 [1.28 sec, ES = 3.75]). Statistically significant increases ($p \leq 0.001$) occurred in the COMB2 group in L-Run test (Seconds) (COMB2 [1.14 sec, ES = 2.15]) (Table 3). Significant differences ($p \leq 0.001$); ($p \leq 0.001$) in L-run test were observed after training in the magnitude of the increase between both COMB1 and COMB2 group and PL. No Significant differences ($p \leq 0.234$) in L-run test were observed after training in the magnitude of the increase between COMB1 and COMB2 group (Table 4).

Table 4.

Differences between the three groups in the training effects

Test	Baseline \pm SD	P
CMJA	COMB1 vs PL	0.749
	COMB1 vs COMB2	0.847
	COMB2 vs PL	0.861
L-Run	COMB1 vs CG	<0.001
	COMB1 vs COMB2	0.234
	COMB2 vs PL	<0.001

Discussion

The aim of this study was to examine the effect of substituting some regular in-season training with 6 weeks of biweekly PL training, combined PL with short sprints and COD training or, a combined PL with strength, short sprints and COD training in children (10–12 years) soccer players in an attempt to maximize physical performance (i.e., jumping and agility). In this context, we accept our hypothesis in that the two combined plyometric methods in-season would improve both jumping and COD performance and a PL training group would improve jumping performance significantly over a short period of time in a group of children soccer players. These results tend to support most of the previous published studies performed examining these types of training interventions with young soccer players (Marqués et al., 2013; Otero-Esquina et al., 2017;

Sáez de Villarreal, Suarez-Arrones, Requena, Haff, & Ferrere, 2015).

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). This success on improving jump height during PL training are attributable to neural adaptations rather than morphologic changes (Sáez de Villarreal et al., 2008). The findings of the present study are in agreement with these authors because there were no interaction or time effects with regard to the muscle mass component. Moreover, In younger children, even though their neuromuscular system is not completely matured (Smits-Engelsman et al., 2003), the improvement of muscle power depends on neural factors rather than muscle strength (Thomas et al., 2009). Nevertheless, neither muscle mass nor neuromuscular variables were assessed in the present study. Further studies focusing on neuromuscular factors are required 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 plyometric 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). In this study, significant improvements

were observed in vertical jump between baseline and post-test in the combined groups, what is in accordance with the findings obtained in several recent investigations performed in young soccer players where incorporate the use of loaded and unloaded combined plyometrics 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, Suarez-Arrones, Requena, Haff, & Ferrete, 2015). Furthermore, Our data are in agreement with investigations in young soccer players which have described improved jump performance following combined plyometrics with strength sprints and COD training (Franco-Márquez et al., 2015; Rodríguez-Rosell et al., 2017, 2017). However, we hypothesized that the combination of methods would obtain better results than the group that performed only PL, besides the results show an improvement compared combined groups above PL, no significant improvements were obtained. Similar results obtain Arabatzi et al. using a combined method (Arabatzi et al., 2010). Meanwhile, a common trend in training programs indicates that a combination of methods is more effective for enhancing performance rather than stand-alone approaches (Adams et al., 1992). Further studies are needed to corroborate if the combination of methods is more beneficial for the vertical jump than the isolate use of PL.

Some studies examined the effects of combined training on COD and observed no gain after training (Arede et al., 2019; Beato et al., 2018; Michailidis et al., 2019). Moreover, in this study, significant improvements were observed in COD test between baseline and post-test in the combined groups what is in accordance with the findings obtained in several recent investigations (Aloui et al., 2021; Hammami et al., 2020; Hammami, Gaamouri, Shephard, et al., 2019; Makhoulouf et al., 2018; Sáez de Villarreal, Suarez-Arrones, Requena, Haff, & Ferrete, 2015).

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. Other authors did obtain differences when using specific exercises (e.g., lateral bounds, unilateral hops, and angle hops) in the plyometric program compared to jumping exercises that were nonspecific to COD (i.e., vertical jumps) (Faigenbaum et al., 2007; Pienaar & Coetzee, 2013). The results of this study suggest that performing COD exercises combined with PL obtains better results than PL training alone, even though these exercises are specific.

Moreover, the protocols proposed in the current study used a training frequency of 2 sessions a week that seems a sufficient stimulus to improve power parameters in young players. To understand the adaptations that underlie after the training program 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.

In summary, this data clearly demonstrated that adding combined plyometric and sprint training in previously moderately trained pubertal soccer players seems to be a good stimulus for improving jumping and agility ability. Both groups performed better than the PL group in the COD test and jump performance was similar. taking into account that the number of jumps was lower, so these results indicate that combined methods provide us with similar results for the jump but at the same time it allows us to improve other performance variables without spending more time. It seems to be a more interesting methodology than an isolated one. Nevertheless, the hypothesis that there would be difference between final measures contributing to athletic performance between the COMB2 over the COMB1 in jumping and COD performance is rejected.

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 youth 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 female players). The third limitation is associated with the design selected for this study. Authors compared 3 training protocols without the involvement of a control group.

Conclusion

In conclusion, the replacement of some low-intensity soccer drills with PL combined with strength, sprints and COD exercises during the warm-up may be one potential option to optimize jumping and COD ability during the in-season soccer training.

Future studies may wish to extend these results to other genders, age groups, and competitive level of players. These improvements 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 jump performance and COD ability in young soccer players. Therefore, strength and conditioning coaches should incorporate

plyometrics and short sprints with COD training into in-season soccer training to enhance players performance.

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