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Evolution of Physical Performance throughout an Entire Season in Female Soccer Players

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Abstract: The aim of this study was to examine the seasonal variations in relevant indices of physical performance in female soccer players. Twenty-seven female soccer players were assessed at week 2 of the season (pre-season, PS), week 7 (end of pre-season, EP), week 24 (half-season, HS), and week 38 (end of season, ES). Testing sessions consisted of: 1) vertical countermovement jump (CMJ); 2) 20-m running sprint (T20); 3) 25-m side-step cutting maneuver test (V-CUT); and 4) progressive loading test in the full-squat exercise (V1-LOAD). Participants followed their normal soccer training, which consisted of three weekly training sessions and an official match, without any type of intervention. No significant time effects were observed for CMJ height (P = 0.29) and T20 (P = 0.11) along the season. Significant time effects were found for V-CUT (P = 0.004) and V1-LOAD (P = 0.001). V-CUT performance significantly improved from HS to ES (P = 0.001). Significant increases were observed for V1-LOAD throughout the season: PS-HS (P = 0.009), PS-ES (P < 0.001); EP-ES (P < 0.001); HS-ES (P = 0.009). In conclusion, female adapted soccer training may be effective for increasing muscle strength and change of direction ability. The high volume of endurance-type training typically accumulated throughout the season may prevent any sprint and jump improvements.

Keywords: Seasonal variations; female athletes; jump; sprint; change of direction; strength

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1. Introduction

Soccer is one of the most popular sports worldwide. Up to 265 million people practice it [1]. According to the last report of the Fédération Internationale de Football Association, more than 13.3 million women players are officially registered [2]. Despite the growing popularity of women's soccer, there is still limited scientific research focused on female players in comparison with their male counterparts, especially about the physical characteristics and physiological demands related to specific soccer practice [3].

Men soccer players cover, on average, about 10 km of distance per game, with high-intensity runs of 2 to 3 seconds (120-150 times per game) [4]. On the other hand, women soccer players cover a total distance between 4 and 13 km per game, from which, 0.2-1.7 km are covered at high-speed [5]. Although high-intensity actions in matches only account for 8% to 12% of the distance covered, they are considered important for performance capabilities [6]. Indeed, the high-speed distance undertaken by female players increases at higher standard levels of competition [7].

High physical fitness allows players to deal with soccer game demands [5]. Female soccer players show 20 m sprint times ranging from 3.05 to 3.59 s [8–10] and vertical countermovement jump (CMJ) heights between 28 and 43 cm [5]. In this regard, sprint and jump performances may vary according to players' standard level. For instance, Haugen et al. (2012) reported that international female soccer players are 2-5% faster over 20 m than their national-level counterparts [9]. Moreover, international female soccer players jump 8-9% higher than national players [9]. Likewise, the ability to rapidly change of direction (COD) has been suggested as a principal fitness parameter, due to the frequent and explosive directional changes performed by soccer players during the game [11]. In line with sprint and jump performance, it has also shown that COD performance is related to competitive standard [12]. Sprinting, jumping, and cutting abilities may be dependent on the ability to apply force [13]. A recent study has shown that starting female soccer players attain greater strength-based performance than non-starters [14]. These findings support the idea that fitness performance should be assessed to individualize training programs according to their current fitness level and competitive standard.

Previous studies conducted with professional male soccer players have not shown any significant change in jump height throughout the season [15]. Others found that male soccer players improved jump and sprint performances from preseason to midseason, but no further performance gains were observed from midseason onward [16,17]. However, it has been reported that professional male soccer players achieved their best sprint performance at the end of the competitive period [18]. Likewise, other authors have reported significant declines in aerobic capacity and vertical jump from the preseason until the end of the season, although only two time-points were measured [19].

To our knowledge, no study has assessed seasonal variation in high-intensity performance indicators in female soccer players. The professionalism of female soccer has resulted in longer competitive phases within the season and more congested schedules, which may influence players' physical fitness. Therefore, players' physical capacities should be accurately assessed throughout the season, since they provide coaches with information about their physical performance progression as well as their strengths and weakness. Therefore, the aim of the present study was to examine the changes in relevant indices of physical performance throughout a season in female soccer players.

2. Materials and Methods

2.1. Subjects

Thirty-one female soccer players, from two teams, competing in the regional championship, were initially recruited and voluntarily participated in this investigation. Due to injuries, four subjects could not perform all testing sessions and dropped out of the study. Thus, the final dataset was obtained from the remaining 27 participants (21.2 ± 7.6 years, height 1.61 ± 0.07 m, and body mass 61.4 ± 9.6 kg). The subjects were informed about the research procedures and gave their written informed consent to participate. In the case of these participants aged less than 18 years, informed consent was obtained from their parents/guardians. No physical limitations, health problems, or injuries were found that could affect the tests. None of the participants were using drugs, or medications known to influence physical performance. All the procedures performed in this study were approved by the Ethics Committee for Biomedical Research of the Andalusian Government with the number 2355-N-19, following the indications of the International Conference of Good Clinical Practices and were conducted in accordance with the 1975 Declaration of Helsinki guidelines.

2.2. Experimental Approach to the Problem

This investigation was performed over 38 weeks (about 9 months), and it was split into 4 periods: pre-season (PS), end of pre-season (EP), half-season (HS), and end of season (ES). Participants carried out their normal soccer training, which consisted of three weekly training sessions and an official match, without any type of intervention. During these 90-minute training sessions, technical, tactical, and conditioning soccer aspects were worked on (Table 1). On Tuesday, Thursday, and Friday, some strength exercises were conducted focused on injury prevention. On Tuesday, 2-3 sets of 8-10 repetitions of squats and deadlifts were performed with a Russian belt (without external load). Moreover, about 20 unilateral and bilateral jumps were performed. On Thursday and Friday, some accelerations and COD tasks were conducted as follows: 6-10 repetitions of 10-20 m with 30-60 s rest. During the study, players did not perform any other sport or specific conditioning training.

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Table 1. Weekly training scheme over the 38 weeks.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Match	Rest	30% ST 40% TT 30% SG	Rest	10% ST 10% Te 30% TT 20% SG 30% ET	10% ST 10% Te 40% TT 20% SG 20% ET	Rest

Strength training (ST); Tactical training (TT); Small-sided games (SG); Technical training (Te); Endurance training (ET).

Physical performance was examined in week 2 for PS, week 7 for EP, week 24 for HS, and week 38 for ES. Testing sessions consisted of: 1) vertical countermovement jump (CMJ); 2) 20-m running sprint (T20); 3) 25-m side-step cutting maneuver test (V-CUT); and 4) progressive loading test in the full-squat exercise (V1-LOAD). Testing sessions were carried out at least 48 hours after the most recent game. All the measurements were performed at the same time of the day for each player and under controlled environmental conditions (20-22ºC and 55-65% humidity) in a research laboratory. Subjects underwent a familiarization session 2 weeks before the start of the first trial. These sessions were supervised by researchers. Attention was paid to ensuring that proper exercise techniques were used, and detailed instruction was provided for the specific testing procedures.

2.3. Procedures

Before measurements, a 15-minute warm-up was performed, which consisted of: 5 minutes of jogging, joint mobility, and a specific warm-up for every test. During all measurements, participants were encouraged to give their best performance, and performance feedback was given after each trial.

Vertical Countermovement Jump. Jump height was calculated at the nearest 0.1 cm from flight time measured with an infrared timing system (OptojumpNext, Microgate, Bolzano, Italy). Because the take-off and landing positions can affect the jump flight, strict instructions were addressed to all participants to keep their legs straight during the flight time of the jump. The subjects started from an upright standing position, made a downward movement until approximating a knee angle of 90º, and subsequently began to push off at maximal velocity. All participants completed 5 maximal CMJs with their hands on their hips separated by 1-minute rest. The highest and the lowest values were discarded, and the resulting average value was kept for analysis. The specific warm-up consisted of two sets of 10 squats without external load, 5 submaximal CMJs, and 3 maximal CMJs. The test-retest reliability was as follows: intraclass correlation coefficient (ICC) was 0.93 (95% confidence interval (CI): 0.86; 0.97) and the coefficient of variation (CV) was 1.7%.

Running Sprints. Two 20-m straight-line sprints, separated by a 3 minutes rest, were performed on an indoor running track. The fastest sprint time was chosen for further analysis (T20). Photocell timing gates (Witty, Microgate, Bolzano, Italy) were placed at 0 and 20 m. A standing start with the leadoff foot placed 1 m behind the first timing gate was used. The warm-up protocol was comprised of four 20-m running accelerations at 80%, 85%, 90%, and 95% of perceived effort, and one 10-m sprint at 100% effort with 1-minute rest between them. The reliability, measured by ICC (95% CI) and CV was 0.99 (0.98; 1.00) and 2.8%, respectively.

Twenty-five-m side-step cutting maneuver test. In the V-CUT test, the subjects performed a 25-m sprint with 4 CODs of 135º every 5 m. For the test to be valid, the subjects had to pass the line, drawing on the ground, with one foot completely each turn. If the trial was deemed unsuccessful, a new trial was allowed. The distance between each pair of cones was 0.7 m. Subjects performed 2 tests, separated by a 3-minute rest. The fastest time was saved for further analysis. Photocell timing gates (Witty, Microgate, Bolzano, Italy) were placed at the beginning and the end of the trial. A standing start was used with the starting foot positioned 1 m behind the first timing gate. The warm-up protocol consisted of one submaximal trial. The ICC was 0.95 (95% CI: 0.88; 0.98) and the CV was 1.8%.

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Progressive Loading Test in the Full-Squat Exercise. The assessment consisted of increasing loads using the full-squat exercise on a Smith machine (Multipower Fitness Line, Peroga, Murcia, Spain). The full-squat exercise was performed with subjects starting from the upright position with the knees and hips fully extended, stance approximately shoulder width apart, and the barbell resting across the back at the level of the acromion. Each participant descended in a continuous motion until the top of the thighs got below the horizontal plane, then immediately reversed motion, and ascended back to the upright position. Feedback based on eccentric distance traveled and concentric velocity was provided. This was accomplished by using a linear velocity transducer (T-Force System, Ergotech, Murcia, Spain) that registered the kinematics of every repetition at 1000 Hz and whose software provided visual and auditory feedback in real time. Unlike the eccentric phase that was performed at a controlled mean velocity (i.e., 0.50–0.65 m.s-1), athletes were required to execute the concentric phase at maximal velocity. The initial load was set at 20 kg and was progressively increased in 10 kg increments until the mean propulsive velocity (MPV) was 1.00 m·s-1 (range: 0.95–1.05 m·s-1). The load that each subject could lift at 1.00 m·s-1 (V1LOAD) was chosen for further analysis. Subjects performed 3 repetitions with each load. Four-minute rests were taken between sets. The warm-up consisted of one set of 6 repetitions (3-minute rest) with 20 kg. MPV corresponds to the mean velocity of the propulsive phase of each repetition. The propulsive phase was defined as that portion of the concentric phase during which the measured acceleration is greater than the acceleration due to gravity (i.e., < -9.8 m·s-2) [20]. For the MPV attained against 20 kg, the ICC was 0.99 (95% CI: 0.97; 0.99) and the CV was 2.4%.

2.4. Statistical Analyses

The values are reported as mean ± standard deviation (SD). The reliability of the measures was calculated via the ICC with 95% CI, using the one-factor random model, and the CV. Normality of the data and homoscedasticity were verified using the Shapiro-Wilk and Levene tests, respectively. One-way repeated ANOVA measures was used to detect differences between the different time-points in the assessed variables. Bonferroni's post-hoc adjustments were applied for all pairwise multiple comparisons. Associations between variables at PS were examined by Pearson's correlation analysis. Statistical significance was established at the level of $p \leq 0.05$. Statistical analysis was carried out using SPSS version 25 for Windows (IBM Corp., Armonk, NY, USA).

3. Results

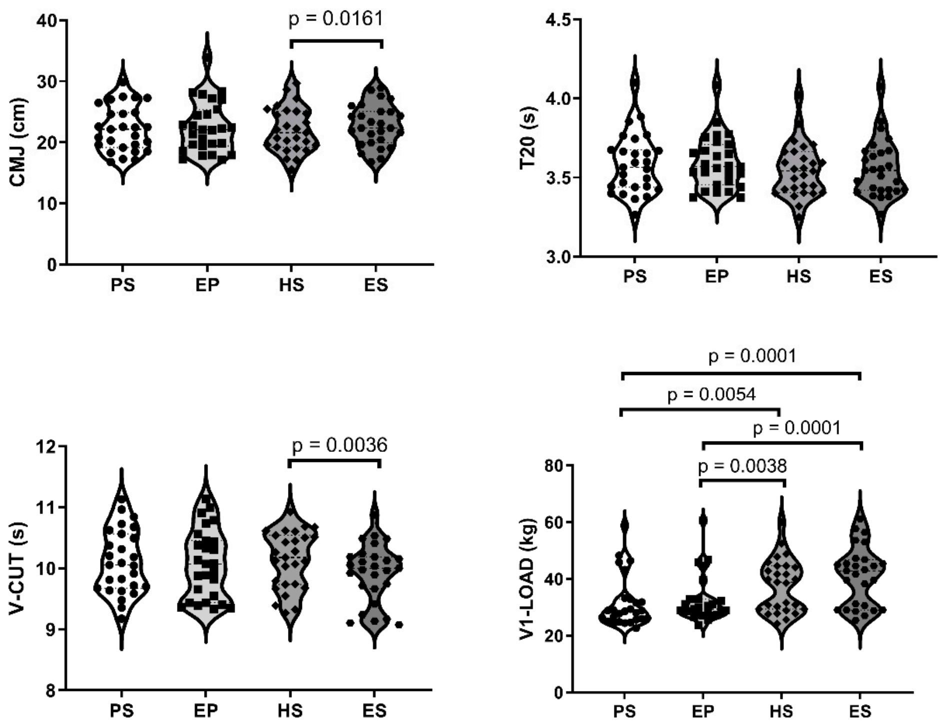
The descriptive characteristics of physical performance in female soccer players throughout the different phases of the season (PS, EP, HS, ES) are reported in Table 2.

No significant time effects were observed for CMJ height (P = 0.29) and T20 (P = 0.11) along the season. By contrast, significant time effects were found for V-CUT (P = 0.004) and V1-LOAD (P = 0.001). V-CUT performance significantly improved from HS to ES (P = 0.001). Significant increases were observed for V1-LOAD between almost all measurements throughout the season: PS-HS (P = 0.009), PS-ES (P < 0.001); EP-ES (P < 0.001); HS-ES (P = 0.009). Figure 1 depicts individual responses to the different physical performance indicators assessed throughout the season.

Table 2. Changes in fitness variables of female soccer players (n = 27) during the 4 stages: preseason (PS), end of preseason (EP), half-season (HS), and end of season (ES).

Parameter/Stage	PS	EP	HS	ES	p-value time effect
CMJ (cm)	22.2 ± 3.7	22.6 ± 4.2	22.0 ± 3.6	22.8 ± 3.3	0.29
T20 (s)	3.56 ± 0.19	3.56 ± 0.17	3.51 ± 0.17	3.53 ± 0.18	0.11
V-CUT (s)	9.98 ± 0.50	9.96 ± 0.53	10.07 ± 0.47	9.81 ± 0.47^{HS}	0.004
V1-LOAD (kg)	31.5 ± 9.0	32.5 ± 8.2	37.6 ± 9.2^{PS}	40.9 ± 10.3^{PS,EP,HS}	0.001

Data are expressed as mean ± standard deviation. CMJ: height attained in vertical countermovement jump; T20: time in 20-m running sprint; V-CUT: time in the V-CUT test, which was conducted to assess the change of direction performance; V1-LOAD: absolute load (kg) lifted at a mean propulsive velocity of 1.00 m·s^{-1} in the full-squat exercise. ^{PS} Significant differences with PS at the corresponding time-point (P < 0.05). ^{EP} Significant differences with EP at the corresponding time-point (P < 0.05). ^{HS} Significant differences with HS at the corresponding time-point (P < 0.05).



PS: Preseason; EP:End of preseason; HS: Half-season;ES: End of season

Figure 1. Individual evolution of physical performance throughout the season. Data represent the distribution with the mean (dotted line) of the whole population along different phases of the soccer season (n = 27). CMJ: height attained in vertical countermovement jump (cm); T20: time in 20-m running sprint; V-CUT: time in the V-CUT test, which was conducted to assess the change of direction performance; V1-LOAD: absolute load (kg) lifted at a mean propulsive velocity of 1.00 m·s-1 in the full-squat exercise. Preseason (PS), end of preseason (EP), half-season (HS), and end of season (ES). Individual scores are indicated. Significant differences between different phases of the season are indicated.

Interestingly, along season V-CUT score clearly condensed around the mean of the score of the population in PS whereas V1-LOAD clearly evolved from a low score in PS to a wider distribution at the end of the season in which three different populations can be seen, a population that maintains at the lower score, a numerous population in the center of the distribution and some participants that show high score (Figure 1).

When we determined the percentage of change in physical performance of the participants in the study, we found that only in V-CUT and V1-LOAD, a significant change was found. In the case of V-CUT, most of the participants showed a reduction in the score in comparison with the score in PS. On the other hand, in V1-LOAD most of the population increase the score reading a 100% of increase in comparison with the score at PS. Although not significantly, T20 also showed a tendency to decrease of the score in most of the participants. And in CMJ, the tendency was to increase, specially at the end of the season (Figure 2).

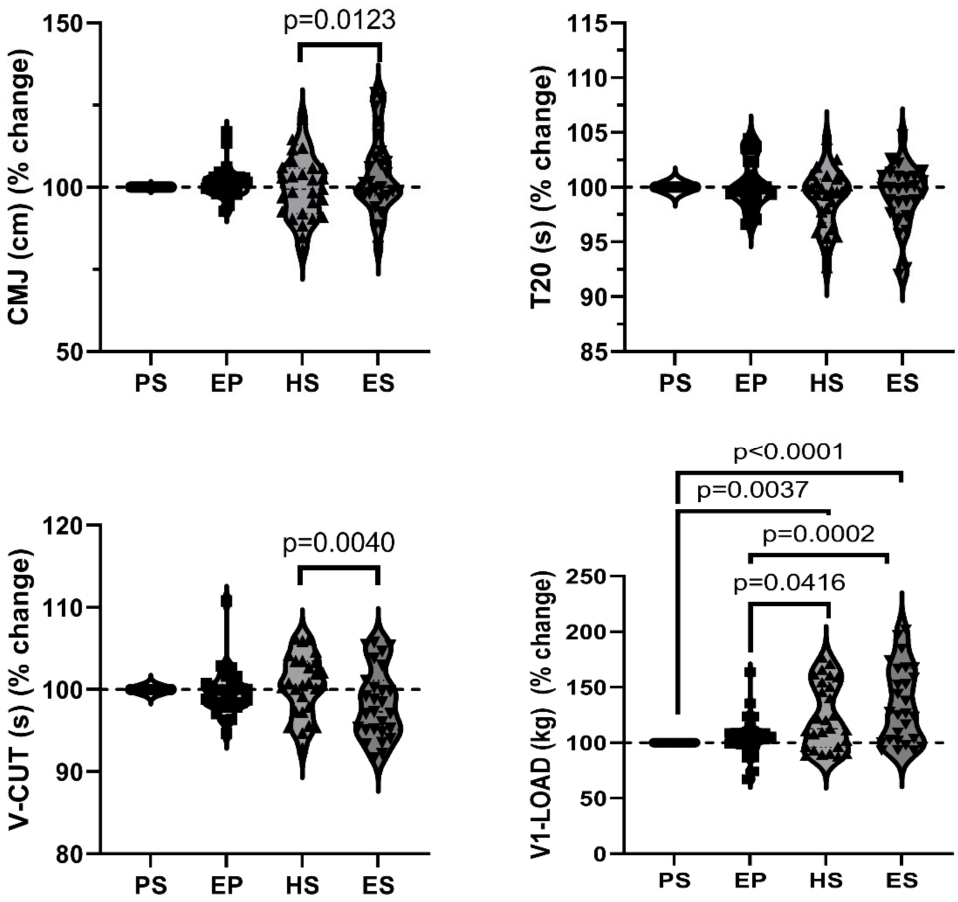


Figure 2. Percentage of change of physical performance along the season. Data represent the distribution of the percentage of change vs PS score of the whole population along different phases of the soccer season (n = 27). CMJ: height attained in vertical countermovement jump (cm); T20: time in 20-m running sprint; V-CUT: time in the V-CUT test, which was conducted to assess the change of direction performance; V1-LOAD: absolute load (kg) lifted at a mean propulsive velocity of 1.00 m·s-1 in the full-squat exercise. Preseason (PS), end of preseason (EP), half-season (HS), and end of season (ES). Individual scores are indicated. Significant differences between different phases of the season are indicated. .

Significant relationships were observed between CMJ height and T20 (r = -0.66, P < 0.001), and between V-CUT and V1-LOAD (r = -0.39; P < 0.05). No significant relationships were observed between the other parameters assessed (Table 3).

Table 3. Relationships between the different high-intensity performance indicators assessed in female soccer players (n = 27).

	T20	V-CUT	V1-LOAD
CMJ	-0.66***	-0.18	0.03
T20		0.32	0.13
V-CUT			-0.39*

CMJ: height attained in vertical countermovement jump (cm); T20: time in 20-m running sprint; V-CUT: time in the V-CUT test, which was conducted to assess the change of direction performance; V1-LOAD: absolute load (kg) lifted at a mean propulsive velocity of 1.00 m·s-1 in the full-squat exercise. Significant relationships are indicated as: * P < 0.05; and *** P < 0.001.

4. Discussion

To our knowledge, this is the first study showing the evolution of physical performance throughout an entire season in female soccer players. Our results indicate that specific soccer training may not be enough to improve jumping and sprinting capability during the season in female soccer players, although it seems to have a positive impact on COD performance and muscle strength, especially in the last stage (ES). Strength and conditioning coaches should know the physical performance of their players throughout the season to design proper training programs.

Jump performance, specifically CMJ, is an accepted indicator of lower body power production in soccer players [21]. Furthermore, it is considered a discriminating variable in male soccer players of different competitive standards [22,23]. Our players jumped about 22 cm and they did not improve during the season. These jump heights do not attain the threshold suggested in previous studies [23] for elite female soccer players: between 28 and 43 cm. In line with our results, previous studies also observed no changes in jump height during the season [15].

Like jump ability, sprint performance in our participants did not change throughout the season. Other authors reported some improvements in jump height and sprint times in the early season (from preseason to midseason), but no further changes in the second half of the season in professional male soccer players [16,17,24]. Soccer players involved in this study ran 20 m in ~3.55 s, which is close to the lowest limit reported in the literature for female soccer: 3.05-3.59 s [8–10]. It has shown that 20 m sprint times in international female soccer players is about 3.30 s [25]. The fact that vertical jump and sprint performance show similar behavior is not strange. Sprint performance and CMJ height have shown strong relationships [26]. Further, significant associations between CMJ height and sprint performance in various sprint distances in female soccer and lacrosse players (r = 0.53 to 0.77) have been reported [27]. These results are in line with the relationships observed in the present study between CMJ height and T20 (r = -0.66, $P < 0.001$, Table 3). Thus, jumping and sprinting seem to share some underlying mechanisms that explain similar behaviors in both tests. A potential explanation for the lack of improvement in jumping and sprinting performance might be related to interfering adaptations resulting from the high volume of endurance training accumulated in the soccer sessions [28]. Therefore, due to the relevance of these fitness parameters in soccer performance and the lack of improvement in them throughout the season, strength and conditioning coaches should consider specific fitness programs targeting to improve jumping and sprinting capabilities when dealing with female soccer players.

Contrary to jumping and sprinting capabilities, COD and muscle strength performances increased throughout the season, especially in the last stage (ES). COD is determined by muscle strength, coordination, and flexibility [29]. Moreover, COD performance is also explained by motor control and technical gesture [30]. Specific soccer practice involves multiple high-intensity COD, along with technical and tactical elements of the game, also stressing cognitive functions [11,29], which may act as COD training. However, these improvements would likely be even greater if a specific COD training program is conducted. Likewise, the increases in muscle strength may explain the improvements in COD performance. Indeed, this suggestion is supported by the significant relationship observed between V-CUT and V1-LOAD (r = -0.39; $P < 0.05$, Table 3). In this regard, some authors highlight the importance of improving leg strength in female soccer players to increase COD performance [31,32]. However, the scarce number of studies in female soccer players hampers the direct comparison of our strength findings. The increases in COD performance during the season are partially in line with previous studies [16,24] that reported improvements in COD performance in the preseason in professional male soccer players, but no further increases were observed during the rest of the season. Notwithstanding, other authors have also observed improvements in COD performance for young elite male soccer players throughout the entire season (preseason and competitive season) [33]. The changes in training volume and intensity over the distinct season stages may explain the evolution of the different capabilities throughout the season. Indeed, it may be argued that the decrease in aerobic training throughout the season may help to increase explosive performance at the end of the season; however, the cumulative stress of the season may attenuate explosive performance-related adaptations. Unfortunately, and as a study limitation, the training load could not be monitored.

Despite it has been emphasized the relevance of muscle strength to general and specific sports skills [34], research on muscle strength in female soccer players is limited. In this regard, traditional strength tests (e.g. one-repetition maximum (1-RM)) present important shortcomings, mainly when they are used with non-resistance-trained subjects, such as: 1) very time-consuming and laborious procedures; 2) high risk of injury when performed incorrectly; 3) they can induce high levels of muscle damage, potentially hampering physical and technical performance on the following days [35], and 4) the value measured may not represent the actual athletes' performance, since they are not familiarized with such loads. Consequently, faster and safer practical methods must be implemented to assess muscle strength in this population. In this regard, the greater the velocity against a given load, the higher the applied force indicating greater strength performance, while a decrease in bar velocity would suggest an impaired ability to apply force [36]. In this regard, female soccer players increased their leg strength throughout the season. As above-mentioned, these strength improvements may be partially responsible for the observed gains in COD ability. However, it seems that specific sprint and plyometric training should be implemented aiming to increase performance in these explosive skills.

5. Conclusions

Female soccer players improved their muscle strength and COD performance throughout the season, but no changes were observed in jumping and sprinting capabilities. These findings may be the result of high-intensity accelerations, decelerations, and COD involved in specific soccer training but also the high volume of endurance-type training typically accumulated in these sessions.

These findings provide relevant information about the seasonal evolution of physical performance in female soccer players. The physical capacities of female soccer players should be tested regularly during the season in order to: 1) assess the effect of a specific season stage, 2) measure individual and team fitness standards, and 3) design individualized training programs based on athletes' requirements.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used All the authors participate actively in the conceptualization, methodology, validation, investigation, writing—original draft preparation and writing—review and editing. Further, all authors have read and agreed to the published version of the manuscript.".

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Conflicts of Interest: The authors declare no conflict of interest.

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