SEASONAL VARIATIONS IN PERFORMANCE AND ASYMMETRY DATA FOR JUMP AND CHANGE OF DIRECTION ABILITIES IN FEMALE SOCCER PLAYERS

ABSTRACT

The study aimed to evaluate the progression of the percentage-based change of direction deficit (%CODD) over a competitive season, along with its correlation with performance tests, and to examine the impact of the magnitude and direction of asymmetry at four stages of the season. Forty-seven (U-16, U-18, and U-20) highly-trained female soccer players performed unilateral vertical (CMJ), and horizontal jumping (HJ), 10-m sprint, and 180º change of direction (COD180) tests. The %CODD was also calculated. Significant group and time effects ($p < 0.05$) were observed in CMJ, HJ, 10-m sprint, and COD180 tests, with U-20 players generally outperforming the U-18 and U-16 groups. Non-significant differences were reported in the %CODD between any time-point or groups throughout the season. Moderate/large significant ($r = 0.44$ to 0.64; $p < 0.05$) relationships were found between %CODD and 10-m. The direction of asymmetry within- and between-tests at all time-points was slight to moderate (k = -0.29 to 0.57). Notwithstanding, 51% of the players showed the best performance in the horizontal jump with the same leg throughout the season, while only 36% in %CODD. This study highlights the importance of developing strategies to improve %CODD depending on the player's position demands. Finally, individually monitoring the magnitude and direction of asymmetry can help practitioners monitor the effects of training and competition throughout the season.

Keywords: longitudinal assessment; bilateral imbalances; muscle strength; team-sports, multidirectional speed

INTRODUCTION

The popularity of female soccer has undergone a significant global increase, along with increased professionalization of women's teams and increased spectator appeal (33). Focusing on the development of female soccer players, optimizing performance and minimizing injury risk are crucial, as well as understanding the physical needs and talent of female players (48). In this regard, the majority of soccer actions often involve some element of unilateral movement competency, and are typically multidirectional in nature (26), such as jumping or cutting. Specifically, such actions include unilateral and bilateral jumps, linear and curvilinear sprints, running in a zig-zag pattern, side-stepping, crossover cutting or running back and forth repeatedly (17, 38). With this in mind, straight sprinting is the most frequent action in goal situations for both assisting or scoring players in professional soccer players (15). Furthermore, in competitive matches, elite female soccer players typically run a total distance of 9 to 11 km (27). Of this total distance, 590 to 840 m are covered at high intensity, between 15.6 and 20 km/h, and 198 to 379 m are completed by sprinting at greater speeds than 20 km/h (27). In this regard, it seems that unilateral and bilateral jumping in several directions and speed abilities (i.e., linear and change of direction (COD) speeds) are essential within decisive situations in soccer, and thus, should be included in testing batteries, as has been widely recognized in the soccer literature to date (8, 17).

The COD deficit has been suggested to be a better representation of "real" COD performance, as opposed to the outcome measure of total time (12). Recently, a new approach to calculating the COD deficit based on the difference in percentage between linear sprint and COD abilities (as opposed to using the raw data) standardizes this metric, thus helping to understand COD ability better when comparing between groups (22). In the specific context of soccer, it is observed that the majority of change of direction movements in soccer are 180º or less, with a significant majority not exceeding 90º (6). Despite its un-specificity, the most common test used to calculate COD deficit is a shuttle sprint test of 10 m (5 + 5 m) with one COD of 180º (10, 12, 39). Furthermore, a recent systematic review of adolescent female soccer players found that the 180ºCOD demonstrated the highest reliability (Intraclass correlation (ICC) = 0.80-0.82; coefficient of variation (CV): 1-1.7%) among 11 retrieved COD tests and was among the most frequently used tests in this population (41). Thus, it seems logical to use the previous test to calculate the COD deficit. In addition, some studies have shown that female team sport athletes, including soccer players, have shorter COD deficits than their male counterparts (36, 45). Koben et al. (31) revealed that players who are faster in linear and curved sprints exhibit larger COD deficits, suggesting that maximum speed does not always correlate with better COD ability. It has also been found that female soccer players have a greater COD deficit than athletes from other team sports, implying less efficiency in changing direction despite their speed in straight-line trajectories (21). These variations suggest that training and injury prevention strategies should be gender- and sport-specific, considering that differences in COD deficits may reflect different biomechanical responses and COD profiles between sexes. This highlights the importance of considering the COD deficit as a critical component in evaluating and training female soccer players.

In recent years, there has been a rise in empirical studies investigating interlimb asymmetries in soccer players (3, 24, 25, 42, 43). In this regard, interlimb asymmetries in strength and power are a practical and valuable tool to detect players at high risk of injury (20), to monitor a successful return to sport after an ACL injury (32), and have been shown to be associated with a reduced jump, speed, and COD performance (2, 18). In addition, the direction of asymmetry refers to the limb that can be considered dominant (i.e., directional dominance) by the asymmetry consistently favoring the same side (4). In this regard, several studies have reported huge variation in directionality, ranging from *slight* to *substantial* levels of agreement (4, 23) and other studies have highlighted the need to obtain asymmetry data from multiple tests and at various times to fully understand asymmetries throughout the season, given its inherent noise and variability (4, 19). However, to the authors' knowledge, no study has analyzed the seasonal variation on the direction of asymmetry and COD deficit in female soccer players. It is essential to assess the physical capabilities of female players throughout the season, especially due to the professionalization of the sport, which leads to longer competitive phases and dense schedules. This provides coaches and trainers with fundamental data on the physical performance progression, strengths and weaknesses of their players, allowing them to identify specific intervention needs to improve under-performing limbs (19). This knowledge is vital for optimizing performance and adjusting training and recovery, given the intensity and length of seasons in professional women's soccer. Therefore, the main aims of the current study were 1) to assess the evolution of the percentage-based COD deficit throughout a competitive season in different age groups, 2) to analyze its relationships with several fitness tests, and 3) to examine how the magnitude and direction of asymmetry is affected through four different times during the competitive season and within each time-point (vertical and horizontal jumping, and the percentage-based COD deficit) in female soccer players. The hypothesis of the study was that the COD deficit, when measured as a percentage, would decrease over the course of a competitive season in female soccer players of different age groups. This study also anticipates finding significant relationships between the COD deficit and performance on a variety of physical performance tests. Furthermore, the magnitude and direction of the asymmetry is expected to show a significant decrease from baseline to the next time point (start of the competitive season), with an overall decreasing trend as the competitive season progresses.

METHODS

Experimental approach to the problem

To evaluate the seasonal variation in the magnitude and direction of inter-limb asymmetry, a repeated measures design was conducted at four different time points during the pre-season (September), mid-season 1 (December), mid-season 2 (March) and the end of the season (May). The same team of researchers conducted the different tests systematically throughout the study, at the same time each day (17:00 to 19:00) and under uniform environmental conditions (approximately 15-20 °C and 20% humidity) on a soccer field. It was recommended that no high-intensity activities be performed during the 48 hours prior to the tests in order to minimize muscle fatigue. In addition, players were advised to avoid consuming caffeine or any other stimulant (i.e., energy drinks or dietary supplements) that could alter their natural performance. The importance of maintaining proper nutrition and optimal hydration in the 48 hours prior to testing was also emphasized. One week before the start of the study, players performed two familiarization tests (jump, linear sprint, and COD) to mitigate any learning effects.

Subjects

Forty-seven (U-16 to U-20), highly trained female soccer players (U-16, age, 15.2 ± 0.38 years; height, 160.9 ± 5.14 cm; body mass, 55.0 ± 7.63 kg; U-18, age, 16.9 ± 0.43 years; height, 159.7 ± 5.42 cm; body mass, 56.6 ± 6.87 kg; U-20, age, 18.9 ± 2.0 years; height, 162.7 ± 5.81 cm; body mass, 59.0 ± 6.40 kg) volunteered to participate in this study. This sample size (n = 47) was selected to detect moderate differences (ES: 0.25) for an

ANOVA of repeated measures through within-between interaction at 80% power and alpha of 0.05 according to G*power *(version 3.1.9.6)*. All players had trained at a soccer club for a minimum of four years. All teams participating in the study trained three times a week, with each on-field technical and tactical training session lasting 90 minutes. In addition, they had a weekly physical preparation session of 90 minutes, which included speed, agility, and quickness training, as well as injury prevention and coordination exercises to maintain their fitness levels. Each team also participated in a match during the weekend. To better contextualize the variations observed in physical performance, we have provided an example of how technical and physical training was periodized (Table 1 and 2) throughout the pre- and in-season periods. At the time of the study, all players were competing at both national and regional levels, such as in the Spanish National League and the Aragon Territorial League of female soccer. They were healthy and did not suffer any disease or injury that could affect the results at the time of the study. Consent was obtained from the parents or guardians of all participants. The research was conducted in accordance with the Declaration of Helsinki (2013) and received prior approval from the local ethics committee (CP19/039, CEICA, Spain).

*****Insert Table 1-2 near here*****

Procedures

A warm-up protocol of the rise, activate, mobilize, and potentiate (RAMP) system was performed before the tests (29). The "activation" phase consisted of dynamic movements and exercises specifically designed to activate the key muscle groups used in the tests. This was followed by the "mobilize" phase, which included dynamic stretching to improve range of motion and joint mobility. Finally, the "potentiation" phase was designed to prepare the neuromuscular system, incorporating specific exercises that imitated the movement patterns and intensity of the tests to be performed. The sequence of physical tests was strategically structured to assess physical performance in a progressive manner (jumping, sprinting, and changing direction). Finally, for the field tests, players wore athletic shoes for jumping tests and soccer boots for linear sprint and COD tests.

Unilateral Countermovement Jump Test

The assessment was conducted three times, allowing for 45-second rest between attempts, with the top result being recorded. Players were instructed to jump on one leg, hands on hips, and flexed the other leg to 90° at hip and knee during CMJL and CMJR (*Optojump, Microgate, Bolzano, Italy*). The jump was considered invalid if an improper technique was performed such as not keeping hands on hips or no landing on the same leg was done. The uniform warm-up involved 1 set per limb, each with 4 increasingly elevated jumps (40). The variables analyzed included the one-legged left CMJ (CMJL) and the one-legged right CMJ (CMJR). The intra-class correlation (ICC) was 0.95 to 0.99 and the coefficient of variation (CV) was 3.6% to 4.8% in this test.

Unilateral Horizontal Jump Test

The HJL and HJR performance was assessed using a measuring tape through three attempts, with a 45-second rest between jumps, and the best result was used for further analysis. Leg swing was permitted during propulsion, and one-leg landings were mandatory. Only jumps where the participants maintained balance and held the final position were recorded. The standardized warm-up consisted of one set for each leg, comprising four jumps of progressive intensity (40). The variables analyzed included the one-legged left horizontal jump (HJL) and the one-legged right horizontal jump (HJR). The ICC values were observed to be between 0.92 and 0.98, and the CV was recorded in the range of 1.6% to 3.8%.

10-m sprint test

Running speed was evaluated by 10-m sprint time. Time was recorded with double-beam photoelectric cells (*Witty, Microgate, Bolzano, Italy*). The front foot was placed 0.5 m before the first timing gate whilst adopting a 2-point staggered stance. Timing gates were placed at 0.75 m height and 1.5 m distance between each other. The 10-m sprint was performed two times, separated by at least 3 min of passive recovery. The ICC ranged from 0.75 to 0.79, while the CV varied between 1.8% and 2.2%.

180° Change of direction test

A 10-m shuttle-sprint test was performed. The subject sprinted from the start/finish line, crossed the 5-m line with either right or left foot, and turned 180° to sprint back to the start/finish line. The front foot was placed 0.5 m before the first timing gate whilst adopting a 2-point staggered stance. Timing gates were placed at 0.75 m height and 1.5 m distance between each other (*Witty, Microgate, Bolzano, Italy*). Players executed two valid trials with each foot (first, left, and second, right) in alternating order, separated by two minutes, with the faster retained for calculation. The warm-up protocol consisted of two submaximal trials per side. The variables analyzed included the one 180 COD with left (COD180L) and right (COD180R) legs. The percentage-based change of direction deficit was calculated using the formula: ((COD time – 10 m sprint time)/10 m sprint time) x 100 (2). The ICC value was 0.80 and the CV was 1%.

Statistical analyses

All statistical analyses were performed using SPSS (*version 25, IBM, New York, NY, USA*) and Microsoft Excel (*version 2016, Microsoft Corp., Redmond, WA, USA*). The reliability of the measures was calculated via the ICC and the CV. Data are presented as mean ± SD. Normality was assessed using the Kolmogorov-Smirnov test and showed all variables as normally distributed variables, with the exception of inter-limb asymmetries. A 4 (1, 2, 3, and 4 time-points) x 3 (U-20 vs. U-18 vs. U-16) repeated measures analysis of variance (ANOVA) was developed. If the ANOVA was significant (time, group, or time-group interaction), a Bonferroni's correction to post-hoc comparisons was conducted. Kruskal-Wallis (between-group) and Friedman's (within-group) tests analysis of variance were conducted to determine differences in asymmetry scores, with statistical significance set at $p<0.05$. Eta squared values were used to establish the magnitude difference. Threshold values for eta squared (η^2) statistics were >0.01 (small), >0.06 (medium), and >0.14 (large). Pearson's correlation coefficients were calculated to establish the relationships between the percentage-based COD deficit with the rest of performance variables at any time-point (1, 2, 3, and 4). The magnitude of the correlation (*r* (95%CI)) between variables was assessed with the following thresholds: ≤0.1=trivial; >0.1–0.3=small; >0.3–0.5=moderate; >0.5–0.7=large; >0.7–0.9=very large; and >0.9–1.0=almost perfect (3). Kappa coefficients were calculated to determine the levels of agreement for how consistently an asymmetry favored the same side (direction of asymmetry) when comparing between COD tasks. This method was chosen because the Kappa coefficient describes the proportion of agreement between 2 methods after removing any agreement by chance (1). Kappa values were interpreted in line with suggestions from Viera and Garrett (4), where <0 = poor, 0.01-0.20 = slight, 0.21-0.40 = fair, 0.41-0.60 = moderate, 0.61-0.80 = substantial, and 0.81-0.99 = almost perfect.

RESULTS

Table 3 shows between-group and between-time point differences. A significant ($p<0.05$) group effect was found in CMJR ($\eta^2=0.18$), CMJL ($\eta^2=0.97$), HJR ($\eta^2=0.15$), HJL ($\eta^2=0.23$), 10-m ($\eta^2=0.52$), COD180R ($\eta^2=0.49$), and COD180L ($\eta^2=0.51$). Post-hoc comparisons showed significant differences ($p<0.05$) between U-20 players and U-18 and U-16 groups in 10-m, COD180R, and COD180L at all time-points except for 10-m at time-point 1 between U-20 and U-16. HJL was significantly ($p<0.05$) lower in U-16 in comparison to U-20 players at all time-points. Furthermore, U-18 players reported a significantly ($p<0.05$) lower CMJL performance than U-20 counterparts at all time-points.

A significant ($p<0.05$) time effect was found in CMJR ($\eta^2=0.21$), CMJL ($\eta^2=0.37$), HJL ($\eta^2=0.27$), 10-m ($\eta^2=0.17$), COD180R ($\eta^2=0.31$), and COD180L ($\eta^2=0.16$). A significantly ($p<0.05$) better CMJR and CMJL performance was found at time-points 2, 3, and 4 in comparison to time-point 1 in U-20 players. Furthermore, a significantly ($p<0.05$) lower %CODDR was reported in time-point 3 compared to time-points 1 and 2 in U-16 players. A significantly ($p<0.05$) group x time interaction was found in 10-m ($F= 3.979$; $\eta^2=0.31$).

*****Insert Table 3 near here*****

%CODDR and %CODDL were significant ($p<0.05$) and largely ($r = 0.80$ to 0.84) related at all time-points (Figures 1 and 2). Furthermore, significant ($p<0.05$) relationships were found between both %CODD and horizontal jumping with either right ($r = 0.35$ to 0.58)

or left (0.29 to 0.59) legs and 10-m linear sprinting (r = 0.44 to 0.54) at all time-points (Figures 1 and 2).

*****Insert Figure 1 near here*****

*****Insert Figure 2 near here*****

Kappa coefficients and accompanying descriptors for how consistently asymmetry favored the same limb between jumping (vertical and horizontal) and %CODD at each time-point and between-time points of each variable are reported in Table 4. A moderate agreement was presented for CMJ at time-point 1 with 2 and 3. Also a moderate agreement was reported for time point 1 with 2 and 4, as well as 3 and 4. %CODD showed slight to fair agreements in line with the rest of agreements in vertical and horizontal jumping. Vertical and horizontal jumping were moderately agreed at time-point 4.

*****Insert Table 4 near here*****

DISCUSSION

The main aim of this study was to assess the evolution of the percentage-based COD deficit throughout a competitive season in different age groups of women soccer players. In addition, the relationships of several fitness tests to COD deficit were evaluated and determination of the way in which the direction of asymmetry was affected at four different times during the competitive season was assessed. The main findings were: 1) the percentage-based COD deficit showed no meaningful improvements throughout the season in any age group; 2) unilateral horizontal jumping and 10-m sprinting were moderately and largely related to the percentage-based COD deficit suggest the need to include unilateral horizontal jumping and sprinting exercises in training programs to improve COD ability, 3) between the beginning of the season and the next time-point (start of the competitive season), female players showed the most significant magnitude of the direction of asymmetry in all performance variables decreased as the competitive season progressed indicating that competitive game may naturally promote a balance of fitness variables and 4) half of the players (i.e., 51%) kept consistency in the direction of asymmetry all the season in horizontal jumping, while only 36% of players did it on the percentage-based COD deficit suggesting different levels of adaptability in the training of these fitness variables.

To the best of our knowledge, this is the first study analyzing the variation of percentage-based COD deficit across the season in female soccer players. Previous studies indicated no significant seasonal variations in either jumping or COD deficit asymmetry in male soccer players (2, 7). However, significant differences have been found in several abilities throughout the season in female soccer players. While significant improvements ($p<0.05$) have been reported in COD ability and 10-m sprint times from mid- to end-season, significant impairments were established from pre- to mid-season in vertical jumping and

10-m sprint time in youth female soccer players (14). Such performance decrements might be attributed to a congested calendar found in soccer at the beginning of the season (30), highlighting some difficulties in developing specific physical abilities during the in-season period (46). Specifically, the absence of significant differences between time points in our female sample suggests a two-fold situation: 1) a possible test (i.e., percentage-based COD deficit) insensitivity in identifying variations in COD deficit scores over the season or 2) specific strength and conditioning contents development to improve the percentage-based COD deficit. The program detailed in Table 2, which includes exercises such as barbell front squats and Bulgarian squats, was systematically integrated into the competitive schedule (Table 1). This structured approach which focused on improving lower extremity strength and thus similarly improving linear sprinting and COD ability, may have been critical in maintaining consistent performance levels. Therefore, coaches and physical trainers should implement a personalised methodological approach, considering gender differences, which is adjusted to the individual needs and progress of female players throughout the competitive season. This involves the implementation of periodic performance tests to ensure their effectiveness in detecting significant variations in physical performance, allowing for appropriate adjustments in training. In addition, the inclusion of specific exercises aimed at strengthening the lower extremities is recommended given their critical relevance in maintaining and improving COD and sprint performance. Finally, future studies should focus on training programs to enhance the ratio between linear and multidirectional speed represented through the percentage-based COD deficit.

Despite the current study reporting no significant difference between age groups in the percentage-based COD deficit, a gradual decrease was observed. Thus, as alluded to earlier, this trend can be attributed to the structured strength and conditioning training described in Table 2 and applied throughout the season (Table 1). Strength exercises aimed at improving lower extremity abilities, crucial for soccer skills, were an integral part of this program. In addition, planned variation in training intensity and rest days were likely decisive in improving recovery and athletic performance, thus contributing to the small decrease in the percentage-based COD deficit over time. Unfortunately, there is a lack of research comparing the percentage-based COD deficit between age categories, limiting opportunities for comparative analysis. Regarding COD ability, similar results have been reported in female soccer players (U12 to senior level) (28), indicating significant differences in COD ability at different ages and revealing an improvement in this ability between 16 and 17 years. Conversely, a progressive decline in COD ability was provided from U15 to the senior level, suggesting that aging may negatively impact this ability (37). These discrepancies could be attributed to factors such as the type of COD test used (e.g., Ziz-zag test, COD90, or COD180), the frequency of training sessions per season (e.g., 3 vs. 2 sessions per week), and the ratio impact between body mass and growth. As soccer players mature, the natural growth prompts an increase in body mass and changes in body composition, which can affect their COD and sprinting times (37, 47). It may be possible that adding weight can increase the mechanical demands on the body during rapid directional changes and sprints, potentially reducing the COD performance deficit, as observed in our female sample and other studies using male players (37, 47). Adapting training to age groups by adjusting intensity and rest periods is essential to maximise recovery and sporting performance, especially in the development of COD ability in soccer players. Coaches and physical trainers should prioritise strengthening this skill in the age groups most susceptible to improvement by implementing specific exercises before the appearance of age-related decline. With natural growth and changes in body composition affecting COD and sprint times, it is essential to include exercises that improve muscular strength and endurance to support the mechanical demands of fast COD movements.

Small to moderate significant ($p<0.05$) associations ($r = 0.29$ to 0.58) between right/left horizontal jumping and the percentage-based COD deficit (i.e., higher left horizontal jump = larger percentage-based COD deficit) have been observed in our study. Similar results were established in female soccer players where CMJ height was associated with a larger COD deficit ($r=0.91$; $p<0.001$) (13). Whilst no relationship was reported between vertical and horizontal jumping and COD deficit in female rugby players (35), vertical jumping and the COD deficit in female soccer players (34) and bilateral jumping and the COD deficit in a mixed-sex cohort of recreational athletes (36) were significantly associated. In addition, other studies reported a significant negative correlation between vertical jumping and the COD deficit in female soccer players (r: -0.34 to -0.75; $p<0.05$) (13, 44). To the authors' knowledge there are few studies which have used unilateral jumping tests (16, 36, 44), and none of them agree with the results of the present investigation. Fernandes et al. (16) found no significant predictors of COD deficit in young male soccer players using single leg CMJ and single leg drop jump. Another study involving a more diverse group that included both sexes and several sports indicated significant relationships between COD tests and vertical and horizontal jump tests ($r=-0.43$ to 0.61; $p<0.05$), but no significant relationship with COD deficit (36). In contrast, Thomas et al. (44) revealed significant correlations between unilateral CMJ and COD ability ($r = -0.38$ to -0.60; $p < 0.001$) in adolescent team sport athletes. Current results are difficult to elucidate due to considerable disparities between studies, such as differences in population (adolescents vs. adults), sex (males vs. females), sports studied (soccer vs.

rugby), and types of jumps used (vertical vs. horizontal jump). To improve performance in COD and jumping abilities, it is essential that coaches and physical trainers continuously monitor and adjust training programs to achieve balanced development and prevent increases in COD deficits. Consequently, it is essential to further investigate the impact of jumping direction and the sample's specific features when attempting to investigate the relationships with COD deficit in female soccer players.

Significant moderate to large correlations (r= 0.44 to 0.64; p<0.05) were observed between the percentage-based COD deficit and 10-m sprinting performance in our cohort of female soccer players, with players who accelerated faster showing a lower percentage-based COD deficit. Interestingly, between both variables above female soccer players also showed a very large correlation (r =-0.88 to -0.77), but a moderate correlation was reported in male soccer players (r= -0.38) (34). Similarly, male team sports athletes have obtained no significant correlations between speed measurements (5, 10, and 20 m) and the COD deficit (9, 11, 36). Such differences might be due to gender differences (males vs. females), linear sprinting distance (5, 10, 20, or 30 m), the type of COD test used, the strength profile, or the players' maturation status. Furthermore, despite correlations not implying a cause-effect, the present findings suggest that isolating COD using the percentage-based COD deficit reveals significant associations with 10-m acceleration, indicating moderate to strong relationships. This observation contrasts with findings in similar populations (16). In this regard, the age-variability of the current sample (U-16 to U-20 players) may have influenced the relationships found. Implementing training designed to increase first-step quickness and acceleration not only directly benefits the athletes' ability to perform quick CODs, but also contributes to a decrease in the COD deficit. In addition, training should be personalized by considering the strength profile and maturation status of each player, as these aspects are key determinants in the ability to improve both linear and multidirectional sprinting. Thus, further research is certainly needed to clarify this relationship in female soccer players, and the effect of maturation status should be further considered in adolescent populations to understand its impact on the relationship between linear and multidirectional sprinting.

The magnitude of the direction of asymmetry in all performance variables showed the most significant seasonal variation, particularly between the start of the season and the beginning of the competitive phase and reporting decreases as the season progresses. This trend indicates a natural phenomenon of adaptation or balance inherent to the sport, whereby the game gradually modifies player's patterns over the course of the season. A progressive increase in training intensity and game frequency throughout the season, together with the subsequent adaptation of the physiological system, could imply a greater unbalanced organism. In this regard, unexpected and stochastic situations in jumping, sprinting, and changing direction may modify the direction of asymmetry in each of these actions in a non-linear pattern. In the current study, the highest magnitude of asymmetry was between CMJ and horizontal jumping and was observed between the start of the season and the end of the competitive phase. This tendency is likely to be influenced by the return of athletes from the summer holidays and the decrease in the intensity of competition towards the end of the season highlighting the impact of seasonal dynamics on athletes' performance. To contrary, the values between horizontal jump and the percentage based-COD deficit were low (i.e., slight) throughout the season. There is only one study where the direction of asymmetry has been analyzed with several tests (jumping and COD) in female athletes (1). In this regard, similar results have been found showing from poor to slight magnitudes (k = -0.04 to 0.23). However, the main difference between both studies was whether such a relationship was examined once or several times throughout the season. These findings are consistent with those of previous studies, reinforcing the notion that the magnitude and direction of asymmetry may vary as a function of the task used (5, 19). Therefore, when using the magnitude of asymmetry as the sole measure to understand inherent variability, caution should be taken. In this case, the direction of asymmetry should also be taken into account for a more complete interpretation of results. Coaches and physical trainers are advised to integrate exercises aimed at minimizing the percentage of asymmetries between the lower limbs, adapted to the needs of each player. In addition, it is interesting to establish continuous monitoring to assess asymmetries throughout the season, especially during critical transitions and at the beginning after the holiday break. Assessments should include jump tests and changes of direction to facilitate specific adjustments in training programs. Emphasis should be placed on both the magnitude and direction of asymmetries to develop specific training programs to improve physical performance in women's soccer.

Kappa values for horizontal jumping were noticeably better than those for other tests, showing that 51% of the cohort maintained a consistent direction of limb dominance across the season. In contrast, only 36% of players did so on the percentage-based COD deficit. Despite the relative similarity in the magnitude of asymmetry for horizontal jump and percentage-based COD deficit across the season among all age groups, there was a moderate inconsistency in the direction of asymmetry, indicated by Kappa values ranging from 0.27 to 0.57 and 0.15 to 0.33, respectively. This has been observed in several studies on team sports (4, 5, 19). For example, the only study examining the direction of asymmetry throughout the season in female team-sports athletes showed from poor to fair results in vertical ($k = -0.14$ to 0.25) and horizontal jumping ($k = 0.04$ to 0.24) (19). The current results suggest that the direction of asymmetry is highly variable throughout the season, except for horizontal and vertical jumping. As COD ability is influenced through a wide variety of determinants, including vertical and horizontal jumping, the percentage-based COD deficit resulting from linear and multidirectional sprinting may be more sensitive to being affected. Therefore, it is essential that coaches and physical trainers incorporate exercises that enhance both vertical and horizontal jumping into their training programs. This approach not only helps to improve the ability to perform COD, but also allows or more effective monitoring of asymmetries throughout the season.

The present study has several limitations that must be acknowledged. First, although not underpowered, the limited number of participants restricts the applicability of the results to only the female soccer teams involved in this study. Second, this study was limited to females' soccer players, which limits the applicability of its findings to male athletes or players in other sports. Third, the data were collected at four different times. More robust conclusions could be drawn regarding variations in the magnitude and direction of asymmetry over the season if data were collected more frequently. Fourth, the absence of workload data prevented a comprehensive understanding of seasonal variations in the variables studied. Fifth, individual or group CV were not included to monitor neuromuscular status and fatigue level throughout the season, and future research should include these measurements to provide information on neuromuscular adaptations and fatigue performance in the current population. Finally, the majority of COD in soccer matches occur within 0 to 90º range (6), however 180ºCOD test was included in the current study because this test showed the highest reliability among COD tests and was one of the most prevalent tests performed in this population (41).

PRACTICAL APPLICATIONS

The %CODD seems to be consistent throughout the season in all age-groups, highlighting the importance of developing strategies to improve %CODD depending on the player's position demands. Furthermore, the direction of asymmetry, mainly based on COD deficit, is highly variable and may be affected by the time of the season (i.e., congested calendar). Thus, individually controlling the magnitude and direction of asymmetry can help practitioners monitor the effects of training and competition throughout the season. From these results, it seems essential to adapt training to the specific positional demands of female soccer to optimize performance. The observed variability underlines the need for a personalized approach to assessing the magnitude and direction of asymmetry. Coaches and physical trainers are recommended to incorporate regular assessments of %CODD and asymmetry into performance monitoring protocols. This practice allows for the identification of areas requiring improvement and facilitates real-time adaptation of training programs, which are fundamental to injury prevention and improved change of direction ability, especially during congested match periods.

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Conflict of Interest Disclosure

None of the authors has a conflict of interest to declare, and all authors were involved in the study design, data collection and interpretation, and contributed to the writing of the manuscript.

REFERENCES

1. Arboix-Alio J, Bishop C, Benet A, Busca B, Aguilera-Castells J, and Fort-Vanmeerhaeghe A. Assessing the Magnitude and Direction of Asymmetry in Unilateral Jump and Change of Direction Speed Tasks in Youth Female Team-Sport Athletes. *J Hum Kinet* 79: 15-27, 2021.
2. Bishop C, Brashill C, Abbott W, Read P, Lake J, and Turner A. Jumping Asymmetries Are Associated With Speed, Change of Direction Speed, and Jump Performance in Elite Academy Soccer Players. *J Strength Cond Res* 35: 1841-1847, 2021.
3. Bishop C, McAuley W, Read P, Gonzalo-Skok O, Lake J, and Turner A. Acute Effect of Repeated Sprints on Interlimb Asymmetries During Unilateral Jumping. *J Strength Cond Res* 35: 2127-2132, 2021.
4. Bishop C, Read P, Chavda S, Jarvis P, Brazier J, Bromley T, and Turner A. Magnitude or Direction? Seasonal Variation of Interlimb Asymmetry in Elite Academy Soccer Players. *J Strength Cond Res* 36: 1031-1037, 2022.
5. Bishop C, Weldon A, Hughes J, Brazier J, Loturco I, Turner A, and Read P. Seasonal Variation of Physical Performance and Inter-limb Asymmetry in Professional Cricket Athletes. *J Strength Cond Res*, 2020.
6. Bloomfield J, Polman R, and O'Donoghue P. Physical Demands of Different Positions in FA Premier League Soccer. *J Sports Sci Med* 6: 63-70, 2007.
7. Carling C, Le Gall F, and Dupont G. Are physical performance and injury risk in a professional soccer team in match-play affected over a prolonged period of fixture congestion? *Int J Sports Med* 33: 36-42, 2012.
8. Chmura P, Oliva-Lozano JM, Muyor JM, Andrzejewski M, Chmura J, Czarniecki S, Kowalczuk E, Rokita A, and Konefal M. Physical Performance Indicators and Team Success in the German Soccer League. *J Hum Kinet* 83: 257-265, 2022.
9. Cuthbert M, Thomas C, Dos'Santos T, and Jones P. The Application of Change of Direction Deficit To Evaluate Cutting Ability. *J Strength Cond Res* 33: 1, 2017.
10. Dos'Santos T, Comfort P, and Jones PA. Comparison of Change of Direction Speed Performance and Asymmetries between Team-Sport Athletes: Application of Change of Direction Deficit. *Sports (Basel)* 6, 2018.
11. Dos'Santos T, Thomas C, Comfort P, and Jones P. Comparison of Change of Direction Speed Performance and Asymmetries between Team-Sport Athletes: Application of Change of Direction Deficit. *Sports* 6: 174, 2018.
12. Dos'Santos T, Thomas C, Jones PA, and Comfort P. Assessing Asymmetries in Change of Direction Speed Performance: Application of Change of Direction Deficit. *J Strength Cond Res* 33: 2953-2961, 2019.
13. Emmonds S, Nicholson G, Begg C, Jones B, and Bissas A. Importance of Physical Qualities for Speed and Change of Direction Ability in Elite Female Soccer Players. *J Strength Cond Res* 33: 1669-1677, 2019.
14. Emmonds S, Sawczuk T, Scantlebury S, Till K, and Jones B. Seasonal Changes in the Physical Performance of Elite Youth Female Soccer Players. *J Strength Cond Res* 34: 2636-2643, 2020.
15. Faude O, Koch T, and Meyer T. Straight sprinting is the most frequent action in goal situations in professional football. *J Sports Sci* 30: 625-631, 2012.
16. Fernandes R, Bishop C, Turner A, Chavda S, and Maloney S. Train the Engine or the Brakes? Influence of Momentum on the Change of Direction Deficit. *Int J Sports Physiol Perform* 16, 2020.

17. Filter A, Olivares-Jabalera J, Dos'Santos T, Madruga M, Lozano J, Molina A, Santalla A, Requena B, and Loturco I. High-intensity Actions in Elite Soccer: Current Status and Future Perspectives. *Int J Sports Med* 44: 535-544, 2023.
18. Fort-Vanmeerhaeghe A, Bishop C, Busca B, Aguilera-Castells J, Vicens-Bordas J, and Gonzalo-Skok O. Inter-limb asymmetries are associated with decrements in physical performance in youth elite team sports athletes. *PLoS One* 15: e0229440, 2020.
19. Fort-Vanmeerhaeghe A, Bishop C, Busca B, Vicens-Bordas J, and Arboix-Alio J. Seasonal variation of inter-limb jumping asymmetries in youth team-sport athletes. *J Sports Sci* 39: 2850-2858, 2021.
20. Fort-Vanmeerhaeghe A, Mila-Villarroel R, Pujol-Marzo M, Arboix-Alio J, and Bishop C. Higher Vertical Jumping Asymmetries and Lower Physical Performance are Indicators of Increased Injury Incidence in Youth Team-Sport Athletes. *J Strength Cond Res* 36: 2204-2211, 2022.
21. Freitas TT, Alcaraz PE, Calleja-Gonzalez J, Arruda AFS, Guerriero A, Kobal R, Reis VP, Pereira LA, and Loturco I. Differences in Change of Direction Speed and Deficit Between Male and Female National Rugby Sevens Players. *J Strength Cond Res* 35: 3170-3176, 2021.
22. Freitas TT, Pereira LA, Alcaraz PE, Azevedo P, Bishop C, and Loturco I. Percentage-Based Change of Direction Deficit: A New Approach to Standardize Time- and Velocity-Derived Calculations. *J Strength Cond Res* 36: 3521-3526, 2022.
23. Gonzalo-Skok O, Dos'Santos T, and Bishop C. Assessing Limb Dominance and Interlimb Asymmetries Over Multiple Angles During Change of Direction Speed Tests in Basketball Players. *J Strength Cond Res* 37: 2423-2430, 2023.
24. Gonzalo-Skok O, Moreno-Azze A, Arjol-Serrano JL, Tous-Fajardo J, and Bishop C. A Comparison of 3 Different Unilateral Strength Training Strategies to Enhance Jumping Performance and Decrease Interlimb Asymmetries in Soccer Players. *Int J Sports Physiol Perform* 14: 1256-1264, 2019.
25. Gonzalo-Skok O, Sanchez-Sabate J, Tous-Fajardo J, Mendez-Villanueva A, Bishop C, and Piedrafita E. Effects of Direction-Specific Training Interventions on Physical Performance and Inter-Limb Asymmetries. *Int J Environ Res Public Health* 19, 2022.
26. Gonzalo-Skok O, Tous-Fajardo J, Valero-Campo C, Berzosa C, Bataller AV, Arjol-Serrano JL, Moras G, and Mendez-Villanueva A. Eccentric-Overload Training in Team-Sport Functional Performance: Constant Bilateral Vertical Versus Variable Unilateral Multidirectional Movements. *Int J Sports Physiol Perform* 12: 951-958, 2017.
27. Hewitt A, Norton K, and Lyons K. Movement profiles of elite women soccer players during international matches and the effect of opposition's team ranking. *J Sports Sci* 32: 1874-1880, 2014.
28. Hirose N and Nakahori C. Age differences in change-of-direction performance and its subelements in female football players. *Int J Sports Physiol Perform* 10: 440-445, 2015.
29. Jeffreys I. Jeffreys I (2007) Warm-up revisited: The ramp method of optimizing warm-ups. Professional Strength and Conditioning. (6) 12-18. *Professional Strength and Conditioning*: 12-18, 2007.
30. Julian R, Page RM, and Harper LD. The Effect of Fixture Congestion on Performance During Professional Male Soccer Match-Play: A Systematic Critical Review with Meta-Analysis. *Sports Med* 51: 255-273, 2021.

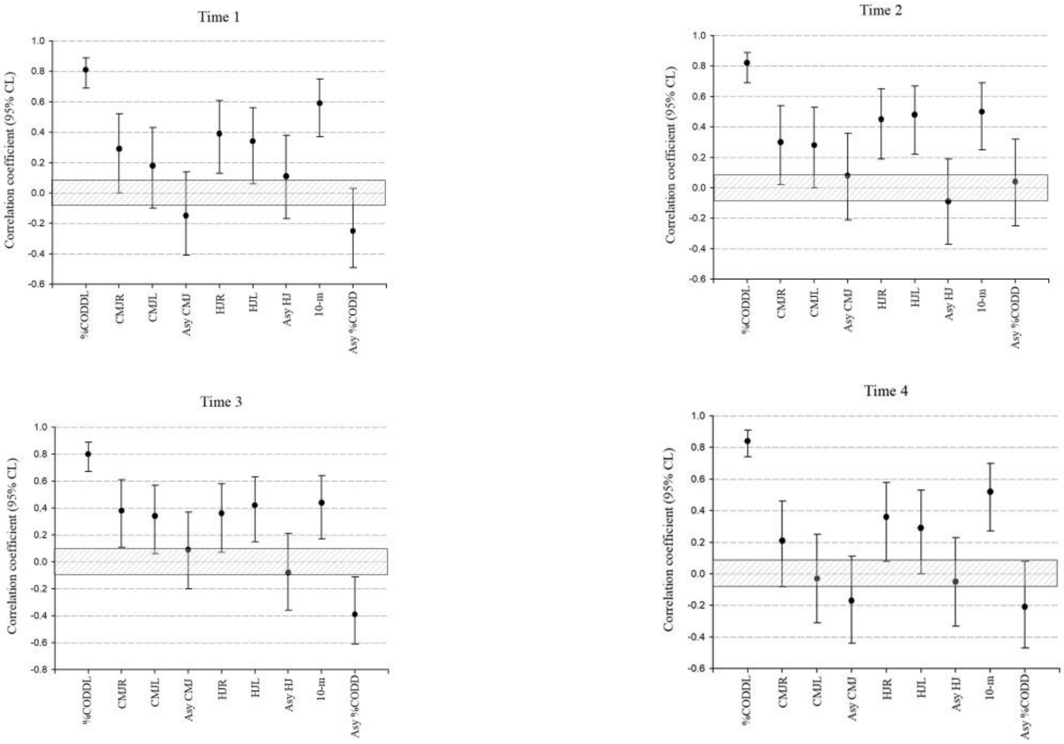
31. Kobal R, Freitas TT, Fílter A, Requena B, Barroso R, Rossetti M, Jorge RM, Carvalho L, Pereira LA, and Loturco I. Curve Sprint in Elite Female Soccer Players: Relationship with Linear Sprint and Jump Performance. *Int J Environ Res Public Health* 18: 2306, 2021.
32. Kotsifaki A, Van Rossom S, Whiteley R, Korakakis V, Bahr R, Sideris V, and Jonkers I. Single leg vertical jump performance identifies knee function deficits at return to sport after ACL reconstruction in male athletes. *Br J Sports Med* 56: 490-498, 2022.
33. Leslie-Walker A, Mulvenna C, and Bramble O. Exploring the motivations and challenges West African female students experience engaging in university sport. *Curr Stud Health Phys Educ* 14: 1-17, 2022.
34. Lockie R, Dawes J, and Jones M. Relationships between Linear Speed and Lower-Body Power with Change-of-Direction Speed in National Collegiate Athletic Association Divisions I and II Women Soccer Athletes. *Sports* 6: 30, 2018.
35. Lockie R, Orjalo A, Amran V, Davis D, Risso F, and Jalilvand F. An introductory analysis as to the influence of lower-body power on multidirectional speed in collegiate female rugby players. *Sport Sci Rev* 25, 2016.
36. Lockie R, Post B, and Dawes J. Physical Qualities Pertaining to Shorter and Longer Change-of-Direction Speed Test Performance in Men and Women. *Sports* 7: 45, 2019.
37. Loturco I, Jeffreys I, Abad CCC, Kobal R, Zanetti V, Pereira LA, and Nimphius S. Change-of-direction, speed and jump performance in soccer players: a comparison across different age-categories. *J Sports Sci* 38: 1279-1285, 2020.
38. Morral-Yepes M, Moras G, Bishop C, and Gonzalo-Skok O. Assessing the Reliability and Validity of Agility Testing in Team Sports: A Systematic Review. *J Strength Cond Res* 36: 2035-2049, 2022.
39. Nimphius S, Callaghan SJ, Spiteri T, and Lockie RG. Change of Direction Deficit: A More Isolated Measure of Change of Direction Performance Than Total 505 Time. *J Strength Cond Res* 30: 3024-3032, 2016.
40. Pardos- Mainer E, Casajús JA, and Gonzalo-Skok O. Reliability and sensitivity of jumping, linear sprinting and change of direction ability tests in adolescent female football players. *Sci Med Football* 3: 183-190, 2019.
41. Pardos-Mainer E, Casajus J, Julian C, Bishop C, and Gonzalo-Skok O. Determining the reliability and usability of change of direction speed tests in adolescent female soccer players: a systematic review. *J Sport Med Phys Fit* 60: 720-732, 2020.
42. Pardos-Mainer E, Casajus JA, Bishop C, and Gonzalo-Skok O. Effects of Combined Strength and Power Training on Physical Performance and Interlimb Asymmetries in Adolescent Female Soccer Players. *Int J Sports Physiol Perform* 15: 1147-1155, 2020.
43. Stern D, Gonzalo-Skok O, Loturco I, Turner A, and Bishop C. A Comparison of Bilateral vs. Unilateral-Biased Strength and Power Training Interventions on Measures of Physical Performance in Elite Youth Soccer Players. *J Strength Cond Res* 34: 2105-2111, 2020.
44. Thomas C, Dos'Santos T, Comfort P, and Jones P. Relationships between Unilateral Muscle Strength Qualities and Change of Direction in Adolescent Team-Sport Athletes. *Sports* 6: 83, 2018.
45. Thomas TDC, Comfort P, and Jones PA. Comparison of Change of Direction Speed Performance and Asymmetries between Team-Sport Athletes: Application of Change of Direction Deficit. *Sports (Basel)* 6, 2018.

46. Tous-Fajardo J, Gonzalo-Skok O, Arjol-Serrano JL, and Tesch P. Enhancing Change-of-Direction Speed in Soccer Players by Functional Inertial Eccentric Overload and Vibration Training. *Int J Sports Physiol Perform* 11: 66-73, 2016.
47. Trecroci A, Rossi A, Dos'Santos T, Formenti D, Cavaggioni L, Longo S, Iaia FM, and Alberti G. Change of direction asymmetry across different age categories in youth soccer. *PeerJ* 8: e9486, 2020.
48. Turner E, Munro A, and Comfort P. Female Soccer. *Strength Cond J* 35: 51-57, 2013.

FIGURE LEGENDS

Figure 1. Correlation coefficients (95% confidence interval) describing the relationships between the percentage-based change of direction deficit with right leg (%CODDR) and the percentage-based change of direction deficit to the left side (%CODDL), unilateral countermovement jump with right (CMJR) and left (CMJL), between-limbs CMJ asymmetry (Asy_CMJ), unilateral horizontal jump with right (HJR) and left (HJL) legs, between-limbs HJ asymmetry (Asy_HJ); 10-m linear sprint, and between-limbs %CODD asymmetry (Asy_%COD) for all players pooled together (n = 47) throughout the season (4 times).

Figure 2. Correlation coefficients (95% confidence interval) describing the relationships between the percentage-based change of direction deficit with left leg (%CODDL) and unilateral countermovement jump with right (CMJR) and left (CMJL), between-limbs CMJ asymmetry (Asy_CMJ), unilateral horizontal jump with right (HJR) and left (HJL) legs, between-limbs HJ asymmetry (Asy_HJ); 10-m linear sprint, and between-limbs %CODD asymmetry (Asy_%CODD) for all players pooled together (n = 47) throughout the season (4 times).


Time 1
Time 2
Time 3
Time 4
Correlation coefficient (95% CL)
%CODDL
CMJR
CMJL
Asy CMJ
HJR
HJL
Asy HJ
10-m
Asy %CODD

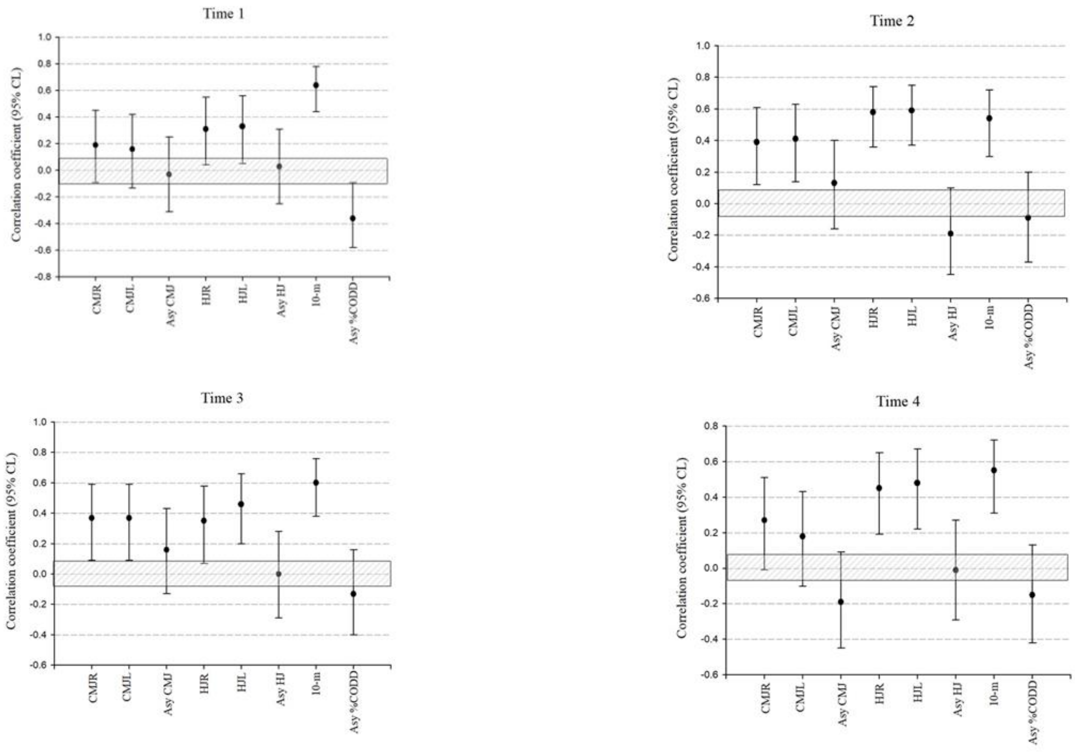

Time 1
Time 2
Time 3
Time 4
Correlation coefficient (95% CL)
CMJR
CMJL
Asy CMJ
HJR
HJL
Asy HJ
10-m
Asy %CODD

Table 1. Summary of the weekly structure of the teams' training sessions throughout the preseason and in-season periods.

	Day week	**Type of training**
Pre-season Schedule	Monday	Strength and conditioning training
	Tuesday	Technical and tactical training
	Wednesday	Rest
	Thursday	Strength and conditioning training
	Friday	Technical and tactical training
	Saturday	Rest
	Sunday	Rest
Season Schedule	Monday	Recovery after match
	Tuesday	Strength and conditioning training
	Wednesday	Technical and tactical training
	Thursday	Rest
	Friday	Technical and tactical training: match preparation
	Saturday	Rest
	Sunday	Match day

Note: Technical and tactical training was performed by the head coach on the pitch and included small-sided games, individual training relates to playing position, simulate real-match, etc. Recovery session after match included foam rolling, joint mobility, static and dynamic stretching at home.

Table 2. Example of a strength and conditioning training in pre-season and in-season.

	Exercise	Sets	Repetitions	Load	Rest
Pre-season	Barbell front squats	3	5	50-70% 1RM*	3-4 mins*
	Sumo deadlifts		5	60-80% 1RM*	
	Barbell lunges		4 each leg	40-60% BM*	
	Hip trust		6	70-85% 1RM*	
	Bulgarian split squat		4 each leg	25-40% BM*	
	Quadruped hip extensions		5	N/A	
	Nordic hamstring		4	N/A	
	Plank		15’’	N/A	
	Dead bugs		15’’	N/A	
	Superman		15’’	N/A	
In-season	Dumbbell diver	3	5	10-15% BM*	3-4 mins*
	One-legged pelvic tilt with free weight		4 each leg	35-55% 1RM*	
	Single-leg box step up with kettlebell		6 each leg	10-15% BM*	
	Barbell standing calf raise		4	15-35% BM*	
	Barbell supersumo squat		4	65-75% 1RM*	
	Weighted one-legged hip trust		6 each leg	5-10% BM*	
	Eccentric box drops with weight		4	5-10% BM*	
	Russian belt posterior chain		5	N/A	
	Russian belt anterior chain		5	N/A	
	Plank		20’’	N/A	
	Plank lateral		20’’	N/A	
	Lumbar bridge		20’’	N/A	

BM: body mass; RM: repetition maximum; N/A: not applicable. * The range of the load for each exercise will depend on the team

Table 3. Between-competitive level (U-20 vs. U-18 vs. U-16) and between-time (1, 2, 3, and 4) differences in physical performance female football players (n=47).

	U-20 (n = 14)				U-18 (n = 15)				U-16 (n =18)			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
CMJR (cm)	13.8 ± 2.75	15.1 ± 2.52*	15.5 ± 2.68*	15.4 ± 2.77*	12.3 ± 2.52	12.3 ± 2.19@	12.7 ± 1.93@	13.6 ± 2.56	12.3 ± 2.78	12.8 ± 3.10	11.9 ± 2.58@	13.5 ± 2.88#
CMJL (cm)	14.4 ± 2.59	15.9 ± 2.87*	15.5 ± 1.84*	17.0 ± 2.91*	12.0 ± 3.18@	11.9 ± 2.77@	12.6 ± 3.07@	13.4 ± 3.41@	12.7 ± 3.51	12.0 ± 2.37@	12.7 ± 2.69@	13.3 ± 2.77@
Asy_CMJ (%)	8.29 ± 6.31	10.7 ± 8.07	7.92 ± 4.89	10.8 ± 10.2	15.8 ± 10.7	13.6 ± 8.02	12.4 ± 7.74	7.25 ± 6.56*#	11.1 ± 8.91	11.5 ± 8.57	9.07 ± 9.26	9.81 ± 8.62
HJR (cm)	138.1 ± 12.7	137.7 ± 10.7	142.6 ± 17.4	140.1 ± 12.4	127.1 ± 10.1	128.6 ± 12.6	126.6 ± 13.1	128.7 ± 12.0	127.6 ± 20.3	124.8 ± 17.7@	120.4 ± 22.2@	130.8 ± 17.9$#
HJL (cm)	138.3 ± 12.4	141.6 ± 11.5	143.0 ± 15.5	144.6 ± 11.3*	127.4 ± 10.4	127.7 ± 12.7@	125.4 ± 16.7	131.7 ± 14.5	126.4 ± 12.5@	129.0 ± 12.2@	121.1 ± 21.2@	133.2 ± 13.7*#@
Asy_HJ (%)	3.98 ± 2.21	4.97 ± 2.73	3.46 ± 2.77	4.31 ± 3.64	2.46 ± 1.93	5.26 ± 5.29	5.69 ± 4.64	5.66 ± 3.95	9.34 ± 5.75@^	8.73 ± 5.71	9.57 ± 5.14@	7.77 ± 5.23
10-m (s)	1.97 ± 0.05	1.92 ± 0.07	1.91 ± 0.05	1.89 ± 0.06*	2.03 ± 0.07@	2.04 ± 0.07@	2.06 ± 0.07@	2.01 ± 0.07@	2.02 ± 0.07	2.03 ± 0.08@	2.07 ± 0.06@	2.01 ± 0.09@
COD180R (s)	2.77 ± 0.08	2.76 ± 0.09	2.74 ± 0.12	2.63 ± 0.13*$	2.95 ± 0.14@	2.94 ± 0.14@	2.91 ± 0.14@	2.88 ± 0.17@	2.99 ± 0.16@	2.99 ± 0.14@	2.94 ± 0.14@	2.92 ± 0.16@
COD180L (s)	2.77 ± 0.09	2.75 ± 0.08	2.75 ± 0.09	2.69 ± 0.10	2.95 ± 0.15@	2.92 ± 0.11@	2.91 ± 0.14@	2.87 ± 0.17@	2.98 ± 0.16@	2.97 ± 0.12@	2.97 ± 0.12@	2.91 ± 0.12#@
Asy_COD (%)	3.79 ± 2.75	3.29 ± 2.15	3.29 ± 1.99	3.33 ± 2.47	2.37 ± 1.54	2.39 ± 1.72	2.60 ± 2.29	2.09 ± 1.69	2.72 ± 1.79	3.21 ± 2.22	3.31 ± 3.10	2.74 ± 2.38
%CODDR (%)	40.5 ± 5.53	43.8 ± 6.31	43.0 ± 7.32	39.2 ± 7.97	45.1 ± 6.21	43.9 ± 7.93	41.6 ± 7.40	43.0 ± 6.63	48.1 ± 6.48@	47.5 ± 7.09	42.4 ± 8.48*$	45.7 ± 7.74
%CODDL (%)	40.7 ± 6.63	43.5 ± 5.56	44.0 ± 4.60	42.4 ± 8.24	44.9 ± 5.51	43.4 ± 7.08	44.7 ± 6.34	44.6 ± 6.19	47.5 ± 5.08@	46.2 ± 6.16	43.8 ± 6.78	44.9 ± 5.71
Asy_%CODD (%)	12.9 ± 9.92	10.3 ± 6.84	10.4 ± 6.23	11.1 ± 7.62	7.50 ± 4.97	7.71 ± 5.73	8.58 ± 7.73	6.82 ± 5.81	8.13 ± 5.23	9.68 ± 6.65	10.8 ± 10.4	8.52 ± 7.11

Note: Mean ± SD; CMJR and CMJL: unilateral countermovement jump with right and left legs; Asy_CMJ: between-limbs CMJ asymmetry; HJR and HJL: unilateral horizontal jump with right and left legs; Asy_HJ: between-limbs HJ asymmetry; 10-m: linear sprint of 10 m; COD180R and COD180L: 10-m shuttle-sprint with one change of direction to right or left; Asy_COD: between limbs COD asymmetry; %CODDR and %CODDL: the percentage-based change of direction deficit to right of left; Asy_%CODD: between-limbs %CODD asymmetry. *p<0.05 vs. time point 1; $p<0.05 vs. time point 2; #p<0.05 vs. time point 3; @p<0.05 vs. U-20 players; ^p<0.05 vs. U-18.

Table 4. Kappa coefficients and accompanying descriptors for levels of agreement describing how consistently asymmetry favored the same side in the pooled sample throughout the season (4 times) and at each time point (vertical and horizontal jumping, and the percentage-based change of direction deficit) (n = 47).

	CMJ2	**CMJ3**	**CMJ4**
CMJ1	0.41 (Moderate)	0.31 (Fair)	0.35 (Fair)
CMJ2		0.41 (Moderate)	0.38 (Fair)
CMJ3			0.35 (Fair)
	HJ2	**HJ3**	**HJ4**
HJ1	0.48 (Moderate)	0.36 (Fair)	0.48 (Moderate)
HJ2		0.27 (Slight)	0.39 (Fair)
HJ3			0.57 (Moderate)
	%COD2	**%COD3**	**%COD4**
%COD1	0.32 (Fair)	0.33 (Fair)	0.15 (Slight)
%COD2		0.25 (Fair)	0.28 (Fair)
%COD3			0.33 (Fair)
	HJ1	**%COD1**	
CMJ1	0.36 (Fair)	-0.27 (Fair)	
HJ1		-0.11 (Slight)	
	HJ2	**%COD2**	
CMJ2	0.15 (Slight)	-0.05 (Slight)	
HJ2		-0.04 (Slight)	
	HJ3	**%COD3**	
CMJ3	0.36 (Fair)	-0.19 (Slight)	
HJ3		-0.03 (Slight)	
	HJ4	**%COD4**	
CMJ4	0.43 (Moderate)	-0.29 (Fair)	
HJ4		-0.06 (Slight)	

*Note: CMJ: vertical jumping; HJ: horizontal jumping; %COD: percentage-based change of direction deficit. 1, 2, 3, and 4 are referred to each time point throughout the season.