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Adolescent female soccer players' soccer-specific warm-up effects on performance and inter-limb asymmetries

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ABSTRACT: No studies have assessed whether changes in physical performance and inter-limb asymmetries (ILA) can be achieved with the FIFA 11+ prevention programme in adolescent female soccer players. The aim of this study was to assess the effect of the FIFA 11+ programme compared with a standard warm-up on physical performance and ILA in adolescent female soccer players. Thirty-six adolescent female soccer players were randomly assigned to an experimental (EG; n = 19) or a control group (CG; n = 17). Unilateral/bilateral countermovement jump (CMJ), drop jump (DJ) and horizontal jump tests, two different change of direction tests, an ankle dorsiflexion test, the Y-Balance test (YBT) and inter-limb asymmetries were measured before and after 10 weeks of training. The results revealed no significant group-by-time interactions in the vast majority of variables ($p>0.05$). Paired t-test revealed significant improvements of the right [effect size (ES):0.56] and left (ES:0.49) CMJ, right (ES:0.74) and left (ES:0.54) DJ (ES:0.74), right (ES:1.27) and left (ES:1.26) posteromedial direction and right (ES:0.89) and left (ES:0.84) posterolateral direction in the YBT in the EG ($p < 0.05$). Right anterior direction in the YBT and V-cut test were significantly improved in both groups ($p<0.05$). For inter-limb asymmetry variables, no significant group-by-time interactions (ES:0 to 0.93) and an improvement between pre- and post-tests (ES:-0.76 to 0.49) were observed. Therefore, the FIFA 11+ programme led to improved unilateral jumping, dynamic balance and reduced lower extremity symmetries of several tests in adolescent female soccer players.

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INTRODUCTION

Soccer has become increasingly popular among females worldwide and according to the Women's Football Survey of the Fédération Internationale de Football Association (FIFA), there were more than 30 million registered women soccer players in 2014 [1]. Soccer is considered a contact sport and demands a wide variety of skills at different intensities. In this regard, soccer players are mainly running throughout the soccer game, while other high-intensity activities such as sprinting, jumping, kicking and changing direction are also important performance factors that require both maximal strength and anaerobic power of the neuromuscular system [2, 3]. Some of the physical demands for adolescent female soccer players during matches have been reported [4] with total distances covered 6-9 km and sprinting with top speeds reaching over 27 km/h^{-1}, but more information is necessary about change of activity such as passing, dribbling, tackling and trapping, repeated sprinting or high-intensity bouts in this population.

At youth standards, popularity is increasing at a rapid rate. There has been almost a 4% increase in participation in the last 5 years in youth female soccer players [5]. During the last decade, there has been a high number of injuries in young soccer players [6]. Quadriceps strains and severe knee (e.g., anterior cruciate ligament) ligament injuries are the most frequent in female soccer players in comparison to their male counterparts [7].

Different multifaceted neuromuscular warm-up programmes to reduce the risk of injury and/or to improve soccer-specific variables have been developed, such as the Sportsmetrics Warm-Up for Injury Prevention and Performance training programme, the Harmoknee injury prevention programme and the FIFA 11+ programme [6-11].

In this regard, the FIFA 11+ is one of the most commonly used injury prevention warm-up programmes in young soccer players [9, 12]. It was developed by a group of FIFA experts [13] as a structured warm-up programme aimed at minimizing the injury risk of the most common injuries in soccer (i.e. ankle and knee sprains, adductor and hamstring strains). Some studies [9-11] have reported on the use of the FIFA 11+ programme in adolescent males and females soccer players (aged 13-19 years), with injury reductions ranging from 21% to 32%. Therefore, different exercises or factors may have been responsible for efficacy of the FIFA 11+ to prevent injuries.

Exercise used in prevention protocols, such as the FIFA 11+, have also been shown to have performance effects among youth soccer players (aged 9-18 years), such as agility [11], jumping height [14] or functional balance [15] improvements. In addition, a meta-analysis concluded that the FIFA 11+ was effective in increasing dynamic balance and exercises performance in soccer players [16]. However, Steffen et al. [8], after the FIFA 11+, did not detect improved performance. The most likely explanation is that the training volume and intensity for each of the exercises were too low to result in performance improvements. Limited and conflicting data are currently available and more studies are necessary.

Recently, lower-extremity asymmetries have been included in test batteries performed by different soccer clubs due to their relation to lower-limb injuries and physical performance [17, 18]. In this regard, female athletes with single-leg hop asymmetries greater than 10% have a 4-fold increase in lower-extremity injuries [16]. Furthermore, an asymmetry greater than 4 cm in the anterior direction during the Y balance test (YBT) is associated with an increase in lower-limb injury risk [17]. In addition, Rey et al. [18] studied the effects of two different eccentric hamstring exercises, the Nordic hamstring and the Russian belt exercises. Both exercises decreased inter-limb asymmetry in the single leg hamstring bridge in junior soccer players. As such, this scarce information makes it challenging to provide solid, evidence-based recommendations. In addition, to the authors' knowledge, no studies have analysed the effects of the FIFA 11+ on inter-limb asymmetries in female soccer players.

Therefore, the aims of the present study were 1) to evaluate the effects of the FIFA 11+ in physical performance in adolescent female soccer players; and 2) to observe whether lower extremity inter-limb asymmetries are decreased in different tests, in a group of adolescent female soccer players. The hypothesis of this study was that there would be an improvement in both physical performance and inter-limb asymmetries from pre-intervention to post-intervention.

MATERIALS AND METHODS

Subjects

Thirty-six adolescent female soccer players (age: 12.7 ± 0.6 years; height: 156.3 ± 7.0 cm; body mass: 52.5 ± 8.3 kg; body mass index: 21.4 ± 0.4 kg/m^2) voluntarily agreed to participate in this study and written informed consent was obtained from both the players and their parents before beginning the investigation. Data collection took place during the seventh month, out of nine, of the competitive season (Table 1). Afterwards, players were randomly assigned (ABBA distribution) to a control group (CG, =17) or experimental group (EG, n=19) based on their ranked physical performance. The study was carried out in conformity with the ethical standards of the Declaration of Helsinki and has been approved by the Ethics Committee of Clinical Research from the Government of Aragón (CP19/039, CEICA, Spain).

Design

Players in the CG performed their habitual warm-up consisting of a combination of running exercises (4-5 min at light intensity), followed by 4-5 min of dynamic mobility emphasizing the lower-extremity muscle groups (gastrocnemius, quadriceps, hip flexors, adductors, hamstrings and gluteals) and technical exercises with the soccer ball (4-5 min). EG players carried out an additional injury prevention programme (FIFA 11+) twice per week for 10 weeks at the beginning of each training session, replacing the habitual warm-up (Fig. 1). Both teams were managed by the same coach and participated in a similar weekly soccer training volume and methodology (2 sessions/week of 90 minutes and 1 match/week). Athletes belonged to the same female soccer division club academy squad (Iberdrola Women's Spanish First Division) and all players were training in a soccer club for at least 4 years. Two weeks prior to the commencement of intervention, four familiarization sessions were executed in the EG to learn the exercises included in the FIFA 11+. Furthermore, two weeks (test) and one week (re-test) before the start of the training intervention, players performed the same testing battery and test-retest reliability was assessed. One week after the end of the training

TABLE 1. Descriptive Data of the Participants, Mean ± SD.

	Age (years)	Height (cm)	Body mass (kg)	BMI (kg/m^2)
Experimental group	12.5 ± 0.4	153.7 ± 6.9	51.2 ± 7.7	21.2 ± 2.2
Control group	13.1 ± 0.3	160.8 ± 4.9	55.9 ± 8.2	21.6 ± 2.8

BMI: Body – mass index.

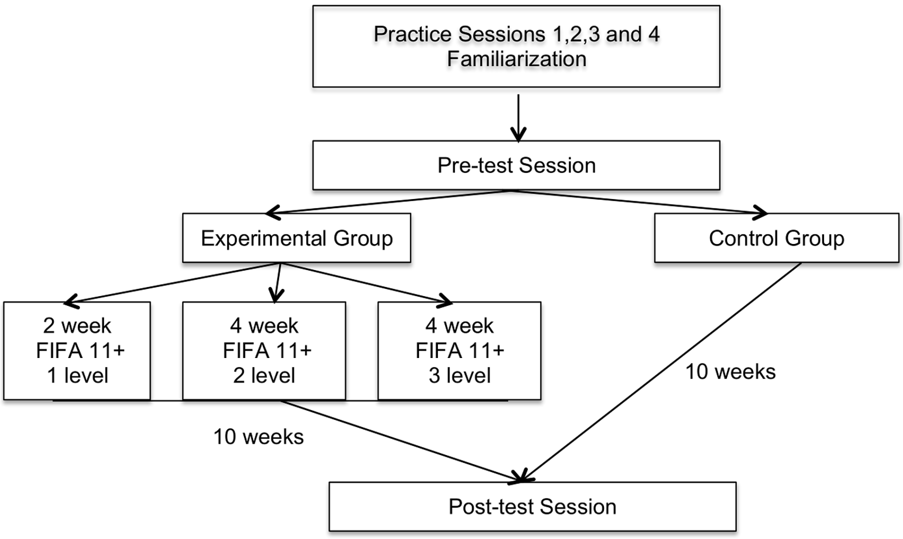

FIG. 1. Project design timeline

intervention, the tests were repeated to examine the effects of the FIFA 11+. The duration of the warm-up was equal for both groups and lasted approximately 15 min.

The FIFA 11+ programme combined cardiovascular activation and preventive neuromuscular exercises and consisted of 3 parts. Part one: six running exercises at slow velocity combined with active stretching and controlled contacts; part two: six exercises focusing on trunk and lower extremities' strength, balance, plyometric and agility components (each exercise had three progression levels); and part three: three running exercises at both moderate and high speed combined with changes of direction (COD). For more details see the manual and instructions freely available on the official website (http://www.fifa.com/development/medical/index.html).

Procedures

Performance tests were completed in 2 hours. These tests were performed on the soccer field. Players wore athletic shoes (jumping tests) and soccer boots (COD tests) in the field/gym tests, whilst balance tests were conducted barefoot. Participants were familiarized with all study tests as they had completed these as part of an assessment battery 4-8 times prior to the study. Two trials for jumping and COD tests and 3 trials for musculoskeletal tests were allowed.

Standing broad jump (SBJ) test. The SBJ indirectly measured horizontal power. This test was measured using a standard measuring tape *(30m M13; Stanley, New Britain, EEUU)* and was assessed as described elsewhere [19]. Each test was performed twice, separated by at least 45 seconds of passive recovery, and the best jump was recorded and used for analysis.

Single leg hop (SLH) test. The SLH indirectly measured unilateral horizontal power. This test was measured using a standard measuring tape *(30m M13; Stanley, New Britain, EEUU)* and was assessed as described elsewhere [20]. The variables used in the analyses were: Single-legged left horizontal jump (SLHL) and single-legged right horizontal jump (SLHR). Each test was performed twice, separated by at least 45 seconds of passive recovery, and the best jump was recorded and used for analysis.

Bilateral countermovement jump test and unilateral countermovement jump test. Jumping height was assessed using a vertical countermovement jump (CMJ) (reported in centimetres) with flight time measured by the Optojump (*Optojump, Microgate, Bolzano, Italy*) and is described elsewhere [20]. Each test was performed 3 times, separated by 45 seconds of passive recovery, and the best jump was recorded and used for analysis. The same criterion was used to assess unilateral CMJ (UCMJ). The variables used for analyses were: 1-legged left CMJ (CMJL) and 1-legged right CMJ (CMJR).

Drop jump test and unilateral drop jump (UDJ) test. Players started at the top of a 31.5 cm high box. Flight time was measured by the Optojump (*Optojump, Microgate, Bolzano, Italy*) and the protocol is described elsewhere [21]. Each test was performed 3 times, separated by 45 seconds of passive recovery, and the best jump was recorded and used for the analysis. The same criterion was used to assess UDJ; however, players stepped forward from the high box (31.5 cm) to the Optojump from the contralateral limb to the test limb. The variables used for analyses were: 1-legged left DJ (DJL) and 1-legged right DJ (DJR).

Weight-bearing dorsiflexion test. Ankle dorsiflexion was evaluated through the LegMotion system *(LegMotion, your Motion, Albacete, Spain)* and the test is described elsewhere [22]. Three trials were allowed with each ankle (i.e., left and right) with 10 seconds of passive recovery between trials. The third value in each ankle was selected for subsequent analysis of weight-bearing dorsiflexion (WB-DF).

Y-Balance test. Dynamic balance was assessed using the OctoBalance device (*OctoBalance, Check your MOtion, Albacete, Spain*), which analyzed three lower limb excursion directions: anterior (YBT-A), posteromedial (YBT-PM) and posterolateral (YBT-PL). The test is described elsewhere [22]. Three trials were allowed with each leg with 10 seconds of passive recovery between trials. The mean result of the three trials in each leg was selected for subsequent analysis [22].

V-cut test. Players performed a 25-m sprint with four CODs of 45º 5 m each, as described elsewhere [20]. Sprint times were measured by dual beam photocell systems (*Microgate, Bolzano, Italy*). The V-cut test was executed twice and 3 min of passive recovery was provided between repetitions. Time in the best (fastest) trial was retained.

180º Change of direction (COD) test. Players performed a 10-m sprint test with a 180º COD. The front foot was placed 0.5 m before the first timing gate (*Microgate, Bolzano, Italy*), a 10-m sprint test was performed and is described elsewhere [20]. The 180º COD was repeated twice with right (CODR) and left (CODL) changes and 2 min of between-repetition recovery was allowed. The best time with each 180º COD was recorded to calculate the mean time that was used for subsequent analyses.

Statistical analysis

Statistical analyses were performed with SPSS for MAC (Version 19.0; SPSS Inc, Chicago, IL). Data are presented as mean ± standard deviation (SD). Normality and equal variance assumptions were checked using the Shapiro-Wilk test and Levene test, respectively. Statistical significance was inferred from $p < 0.05$. A 2 (group) x 2 (time) repeated measures of analysis of variance (ANOVA) was calculated for each parameter. The standardized difference or effect size [ES, 90% confidence limit (CL)] in the selected variables was calculated using the pooled SD (pre- and post-test). Threshold values for Cohen ES statistics were >0.2 (small), >0.6 (moderate), and >1.2 (large) [23]. Only players who participated in >85% of all training sessions were included in the final analyses. Consequently, 4 of the 36 players were excluded due to injury, muscle fatigue or other commitments. As a result, 32 players were included in the final analyses. The final sample sizes for the different groups were n = 15 for CG and n = 17 for EG.

Inter-limb symmetry was calculated using the following formula [24]: Inter-limb symmetry (%) = (stronger limb-weaker limb/stronger limb) x 100.

Relative reliability analysis was examined using the ICC. The typical error of measurement (TEM) was used to examine the absolute reliability. The spreadsheet of Hopkins (Reliability from consecutive pair of trials, xrely.xls (2015)) was used to determine both ICC and TEM, expressed as a coefficient of variation (CV).

RESULTS

ICC and CV results of this study were from 0.83 to 0.93 and 1.5% to 5.3%, respectively. These results indicate good reliability (ICC > 0.67) and acceptable variability (CV < 10%) [25].

Summary results of all tests performed in CG and EG are shown in Table 2.

Strength tests

ANOVA showed significant group-by-time interactions for the SBJ ($p < 0.05$). Paired t-tests revealed significant improvement of the SBJ (ES = 0.30) in the CG but no improvement in the EG ($p > 0.05$). Although the right SLH, left SLH, CMJ, left CMJ, DJ, right DJ and left DJ did not show a significant group-by-time interaction, paired *t*-tests revealed significant improvement between pre-test and post-test in the EG ($p < 0.05$). For the right CMJ, SLH asymmetry, UCMJ asymmetry, and UDJ asymmetry no significant group-by-time interaction and an improvement between pre- and post-tests were observed. Strength results from between-groups analysis are illustrated in Fig. 2A.

Musculoskeletal tests

ANOVA showed significant group-by-time interactions for the right YBT-PM ($p < 0.01$). Paired *t*-tests revealed significant improvement of the right YBT-PM (ES = 1.27) in the EG but no improvement in the CG ($p > 0.05$). However, the left YBT-PM, right YBT-PL and left YBT-PL did not show a significant group-by-time interaction. Paired *t*-tests revealed significant improvement between pre-test and post-test in the EG ($p < 0.05$). Right YBT-A improved significantly in both the CG and EG ($p < 0.05$), but no significant group-by-time interactions were observed. For the left YBT-A, YBT-A asymmetry, YBT-PM asymmetry and YBT-PL asymmetry no significant group-by-time interaction or improvement between pre- and post-tests was observed.

For the flexibility data, no significant group-by-time interaction or improvement between pre- and post-tests was observed. Musculoskeletal results from between-groups analysis are illustrated in Fig. 2B.

Change of direction tests

There were no significant group-by-time interactions of all COD tests. For within-group change from pre-test to post-test, significant impairment was revealed in the V-cut test in the CG (ES: 0.70) and the EG (ES = 0.59). COD results from between-group analysis are illustrated in Fig. 2C.

TABLE 2. Summary results of all tests performed in Control Group and Experimental Group. Mean ± SD

Variable	Control Group				Experimental Group			
	Pretest	Posttest	p	ES (90 CL)	Pretest	Posttest	p	ES (90 CL)
SBJ (m)[$]	1.52 ± 0.22	1.63 ± 0.18*	.033	0.30 (0.07; 0.53)	1.48 ± 0.16	1.49 ± 0.13	.708	0.07 (-0.19; 0.33)
SLH$_R$ (m)	1.23 ± 0.20	1.32 ± 0.19	.153	0.28 (-0.3; 0.60)	1.23 ± 0.16	1.29 ± 0.12*	.017	0.40 (0.15; 0.66)
SLH$_L$ (m)	1.29 ± 0.18	1.36 ± 0.16	.153	0.30 (-0.04; 0.65)	1.25 ± 0.18	1.32 ± 0.14*	.016	0.34 (0.11; 0.58)
% As SLH	91.9 ± 6.37	93.5 ± 5.31[¢]	.653	0.15 (-0.45; 0.74)	92.9 ± 4.74	94.3 ± 5.09[¢]	.453	0.26 (-0.35; 0.87)
CMJ (cm)	22.8 ± 3.12	23.1 ± 6.28	.917	-0.11 (-1.16; 0.94)	20 ± 3.68	22.1 ± 3.39*	.014	0.48 (0.14; 0.82)
CMJ$_R$ (cm)	11.3 ± 1.96	12.3 ± 2.42	.329	0.34 (-0.30; 0.99)	10.5 ± 1.98	11.1 ± 2.37	.446	0.56 (0.30; 0.82)
CMJ$_L$ (cm)	11.4 ± 2.36	11.6 ± 2.68	.810	0.07 (-0.43; 0.57)	10.4 ± 2.36	11.8 ± 2.37*	.004	0.54 (0.25; 0.83)
% As UCMJ	93.1 ± 4.35	91.3 ± 6.87	.179	-0.76 (-1.72; 0.20)	90 ± 5.46	87.3 ± 8.67	.154	-0.62 (-1.32; 0.08)
DJ (cm)	23.3 ± 4.86	24.7 ± 4.55	.309	0.38 (-0.22; 0.97)	21.2 ± 3.44	23.3 ± 3.50*	.007	0.61 (0.24; 0.99)
DJ$_R$ (cm)	13.4 ± 3.48	13.6 ± 3.49	.637	-0.12 (-0.81; 0.56)	11.3 ± 2.25	13.2 ± 2.86*	.002	0.74 (0.39; 1.08)
DJ$_L$ (cm)	13.3 ± 2.94	14.03 ± 3.46	.827	0.05 (-0.45; 0.55)	11.7 ± 2.93	13.4 ± 2.63*	.002	0.54 (0.27; 0.81)
% As UDJ	90.7 ± 5.94	88.5 ± 8.96	.766	-0.29 (-1.89; 1.31)	87.1 ± 9.73	92.5 ± 5.33[¢]	.070	0.47 (0.06; 0.89)
WB-DF$_R$ (cm)	12.4 ± 2.23	12.7 ± 2.97	.261	0.20 (-0.22; 0.61)	12.2 ± 2.17	12.7 ± 2.51	.307	0.20 (-0.20; 0.61)
WB-DF$_L$ (cm)	12.6 ± 2.24	12.9 ± 2.72	.220	0.29 (-0.19; 0.76)	12.3 ± 1.97	12.8 ± 2.26	.217	0.26 (-0.14; 0.65)
% As WB-DF	92.9 ± 4.94	87.3 ± 7.28*	.015	-1.19 (-1.93; -0.45)	91.4 ± 5.65	87.5 ± 10.7	.182	-0.76 (-1.68; 0.15)
YBT-A$_R$ (cm)	58.1 ± 5.67	60 ± 4.05*	.046	0.45 (0.09; 0.81)	56.4 ± 6.22	59.2 ± 5.09*	.026	0.42 (0.12; 0.72)
YBT-A$_L$ (cm)	57.6 ± 5.08	60.1 ± 3.21	.303	0.56 (0.05; 1.08)	56.1 ± 5.45	58.4 ± 5.90	.194	0.40 (-0.05. 0.85)
% As YBT-A	96.1 ± 3.03	94.6 ± 3.29	.164	-0.43 (-0.94; 0.09)	95.3 ± 4.65	94.6 ± 5.12	.601	-0.15 (-6; 0.31)
YBT-PM$_R$ (cm)	74.2 ± 12.8	70.8 ± 16.3	.202	-0.37 (-0.81; 0.08)	61.1 ± 6.39	70.4 ± 7.12*	.000	1.27 (0.90; 1.64)
YBT-PM$_L$ (cm)	68.2 ± 11.3	72.3 ± 12.7	.185	0.40 (-0.12; 0.92)	62.3 ± 6.88	71.9 ± 5.21*	.000	1.26 (0.99; 1.54)
% As YBT-PM	89.8 ± 8.44	90.3 ± 8.37[¢]	.239	0.27 (-0.44; 0.99)	92.3 ± 7.48	93.6 ± 3.50[¢]	.524	0.18 (-0.24; 0.59)
YBT-PL$_R$ (cm)	64.2 ± 12.4	68.9 ± 15.1	.171	0.38 (-0.13; 0.89)	62.3 ± 6.98	69.2 ± 6.40*	.001	0.89 (0.47; 1.30)
YBT-PL$_L$ (cm)	68 ± 13.5	70.5 ± 14.1	.621	0.14 (0.36; 0.65)	59.9 ± 9.50	68.2 ± 5.98*	.001	0.84 (0.49; 1.18)
% As YBT-PL	90.4 ± 6.13	92.2 ± 6.39[¢]	.239	0.4 (0; 0.8)	93.1 ± 5.53	95 ± 4.34[¢]	.273	0.33 (-0.17; 0.82)
V-cut (s)	7.85 ± 0.39	8.16 ± 0.31*	.011	0.70 (0.30; 1.09)	7.89 ± 0.33	8.09 ± 0.33*	.006	0.59 (0.26; 0.93)
180ºCOD$_R$ (s)	2.96 ± 0.13	3.05 ± 0.13	.133	0.53 (-0.06; 1.11)	3.02 ± 0.13	3.06 ± 0.10	.200	0.32 (-0.10; 0.73)
180ºCOD$_L$ (s)	2.96 ± 0.13	3.01 ± 0.11	.271	0.28 (-0.16: 0.71)	3.04 ± 0.14	3.04 ± 0.13	.959	-0.01 (-0.43; 0.41)
% As COD	97.7 ± 2.13	96.2 ± 2.36	.148	-0.44 (-1.23; 0.36)	96.8 ± 1.84	97.7 ± 1.79[¢]	.112	0.49 (-0.02; 1)

R: Right; L: Left; CMJ: countermovement jump; UCMJ: unilateral countermovement jump; CMJ$_R$: one- egged vertical right jump; CMJ$_L$: one-legged vertical left jump; UDJ: unilateral drop jump; DJ$_R$: one-legged drop right jump; DJ$_L$: one-legged drop left jump; SBJ: Standing broad jump; SLH: single leg hop test; SLH$_R$: one-legged horizontal right jump; SLH$_L$: one-legged horizontal left jump; WB-DF: weight- bearing dorsiflexion; YBT: Y-Balance test; YBT-A: anterior direction; YBT-PM: posteromedial direction; YBT-PL: posterolateral direction; 180ºCOD: 5+5 m sprint test with a 180º change of direction; V-cut: 25-m sprint test with 4 x 45º changes of direction; SD: standard deviation; As: asymmetry; cm: centimetres; s: seconds; m: meters; CL: confidence limits; ES: Effect Size* Significant difference between the pre-test and post-test ($p < .05$)

[$] Significant group by time interaction ($p < .05$)

[¢] Decrease limb symmetry index

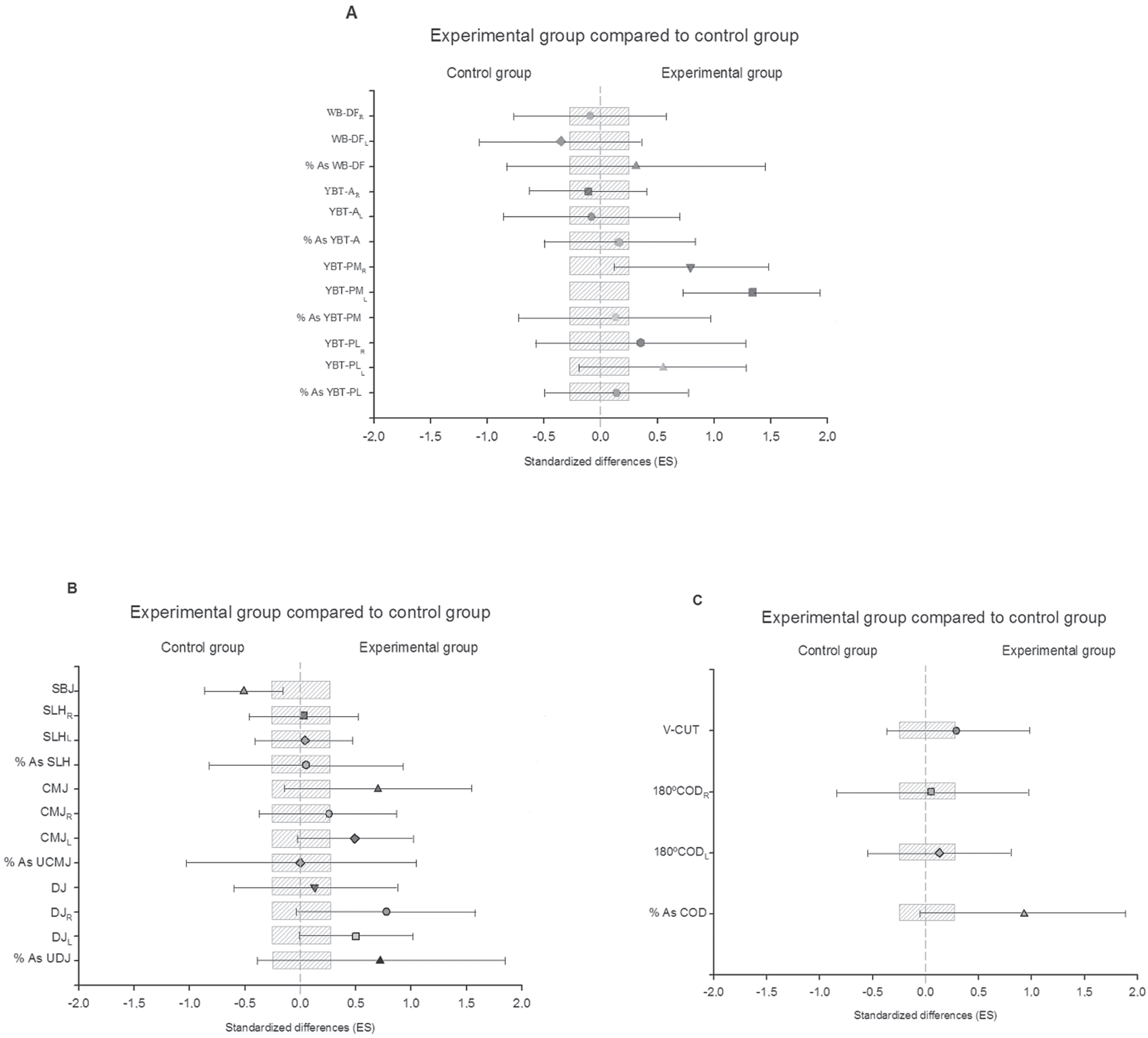

FIG. 2. Efficiency of training group in comparison with control group to improve jumping, agility, balance and flexibility variables. Bars indicate uncertainty in the true mean changes with 90% confidence intervals.
R: Right; L: Left; WB-DF: weight-bearing dorsiflexion; YBT: Y-Balance test; YBT-A: anterior direction; YBT-PM: posteromedial direction; YBT-PL: posterolateral direction; As: asymmetry; CMJ: countermovement jump; CMJR: one-legged vertical right jump; CMJL: one-legged vertical left jump; UDJ: unilateral drop jump; DJR: one-legged drop right jump; DJL: one-legged drop left jump; SLHR: one-legged horizontal right jump; SLHL: one-legged horizontal left jump; As: asymmetry; 180º COD: 5+5 m sprint test with a 180º; V-cut test: 25-m sprint test with 4 x 45º changes of direction.

DISCUSSION

The aims of the present study were to assess the effects of 10-week FIFA 11+ implementation on physical performance and to evaluate asymmetry reduction in skill-related physical fitness tests in adolescent female soccer players.

The main finding was the improvement in dynamic balance and unilateral jumping through the current injury prevention programme. Conversely, no improvements were found in the rest of the performance tests in this cohort of female adolescent soccer players. Furthermore, in 5 out of 8 tests in the EG, asymmetries were decreased (Table 2).

Previously, it has been suggested that the FIFA 11+ provides positive effects on the variables analysed in the present study (jumping ability, range of motion [ROM] or COD) in adolescent females [14, 15]. Similar results were found within our study, with significant improvement in CMJ (6%), 3-step jump (3.4%), Illinois agility test (2%) and 5 out of 6 for reach in the SEBT (4-7%) in the EG. No significant differences were found in the EG in comparison to the CG. Indeed, Steffen et al. [8] analysed whether the FIFA 11+ could improve fitness performance in U-18 female soccer players and there was no difference between the intervention and control groups in the change in performance from the pre- to post-test for any of the tests used. As occurred in our study, no significant differences were reported between the FIFA 11+ group and CG (this group carried out their usual soccer warm-up).

In the EG, the magnitude of change found in jumping power of the vertical, horizontal and drop jumps (ES: 0.07 to 0.74) opposes that of previous studies (ES: -0.22 to 0.37) after a similar injury prevention programme [8, 26-29]. Substantial improvements were observed in all jumping variables, while CG achieved trivial changes in CMJ (ES: -0.11) and DJ with right leg (ES: -0.12). As a result, the between-group analyses showed substantial differences in vertical jumps (CMJ and DJ) at post-test, whereas there were no differences in horizontal jumping. This result might be explained by having fewer drills in the horizontal direction than the vertical direction in the FIFA 11+, and it is similar to the results of the study of Ozbar et al. [30]. In this regard, controversy still exists regarding the effect of these programmes on the jumping ability of female adolescent soccer players with results showing both positive [28, 29] and unclear effects [8, 26]. However, it is worth noting that the main aim of this programme is to reduce injury risk and not improve performance. Therefore, further studies are needed to explore whether the FIFA 11+ can elicit positive neuromuscular adaptations in female adolescent soccer players.

COD ability is one of the most important components in soccer [31]. Its improvement has become a focus of training programmes in adolescent female soccer players [32, 33]. However, trivial results (ES: -0.01 to 0.32) were found in the EG in all COD tests after the FIFA 11+ programme in this study. Similarly, several studies have also shown trivial improvements (ES: -0.8 to 0.27) in different COD tests (e.g., Illinois test, dribbling test, Pro-Agility test) [8, 26]. It is worth noting that COD ability mainly depends on several determinants such as technique, anthropometry, straight sprinting and strength [34]. As such, it might be possible that these determinants were not sufficiently stimulated through the current injury prevention programme, and thus a greater and more specific training stimulus may be needed to develop this complex ability.

Following the FIFA 11+, the YBT directions scores were significantly improved in the EG compared to the CG. Specifically, no significant between-group differences were found in the anterior direction while the EG significantly improved in the posterolateral (ES: 0.84 to 0.89) and posteromedial (ES: 1.26 to 1.27) distances compared to the CG. Similar results using this test have been observed following an eight-week neuromuscular training programme (ES: 0.69 to 0.91) [35] and a four-month study performing the FIFA 11+ (ES: 0.61 to 1.09) [15]. It has been reported that posterolateral and posteromedial direction improvements might be the result of both better neuromuscular control and dynamic balance rather than greater lower-limb strength in female collegiate soccer athletes [36]. As such, it is worth noting that part 2 of the FIFA 11+ consists of several progressive plyometric, balance, and core exercises which can improve with greater neuromuscular control. Thus, the current results might be related to those exercises performed during the intervention. On the other hand, the absence of improvements in the anterior direction after performing the FIFA 11+ was expected because the ankle dorsiflexion ROM also showed no between-group differences. The ankle dorsiflexion ROM improvements may have cancelled out any notable differences between groups in the anterior direction, and therefore a specific group of exercises to enhance ankle ROM needs to be included in warm-up programmes.

WB-DF improved in both groups after the intervention. Therefore, it seems that the training programme performed was ineffective to induce ROM evidence. It has been reported that a static stretching intervention prompted ankle dorsiflexion improvements (ES: 0.30) and even more when including an elastic band within the stretches (ES: 0.85) [37]. Thus, it seems necessary to use a specific intervention if one's goal is to enhance ankle dorsiflexion ROM. Furthermore, a low ROM might be considered as a risk factor to develop a patellar tendinopathy [37]. Consequently, those players who have a low ankle dorsiflexion might be likely to suffer a tendon injury, and thus it might be advisable to include specific exercises within soccer training routines in these particular players.

Side- to-side asymmetry is a current measurement from different clinical tests [38, 39] and it is an important variable to assess the injury risk [40-42]. Previous investigations have reported that collegiate Division I athletes [41] and high school basketball players [42] who showed more than 4 cm of side-to-side asymmetry in the anterior directions were 2.2 times and 2.5 times more prone to suffer a lower-limb injury, respectively. Within our sample, 26.7% of our adolescent female soccer players would be more likely to sustain a non-contact lower-limb injury. In this regard, the current neuromuscular programme reduced the asymmetry in the posteromedial and posterolateral YBT direction (ES: 0.18 to 0.33). It might be possible that this improvement could be obtained through the inclusion of unilateral exercises performed during the intervention. It appears that the FIFA 11+ was effective at reducing the DJ asymmetry, whilst the CG became more asymmetrical. In contrast, the EG became more asymmetrical in the CMJ test. These changes in vertical jump should be interpreted with caution. Practitioners should consider the individual nature of asymmetries when interpreting data relative to these side-to-side differences, and an individualized approach to monitoring asymmetry might be considered to optimize physical performance and reduce the risk of future injury of each female soccer player [43].

However, direct comparisons with adolescent female soccer players are not available, and therefore further studies are required to allow further exploration.

There are several limitations of the current study: the small number of adolescent female soccer players, between-age differences, maturational status of the participants, differences in players' position demands during the matches were not assessed, and data cannot be extrapolated to other populations such as men's soccer or other sports. Cumulative fatigue during the season may impact the results because the intervention was performed at the later stage of the season. Some exercises of the current programme (e.g., plank and side plank) might be difficult for female adolescent soccer players to carry out; therefore these exercises should be modified to increase the participation percentage (e.g., set knees on the ground).

CONCLUSIONS

The FIFA 11+ programme carried out during a 10-week intervention period could be a stimulus sufficient enough to improve different performance variables and reduce inter-limb asymmetries in female adolescent soccer players. This programme significantly improves unilateral explosive and muscular power as well as dynamic and functional balance, which are believed to aid in the prevention of lower limb injuries. The FIFA 11+ also reduces inter-limb asymmetries of skill-related physical tests, which therefore minimizes injury risks. However, COD showed no improvements. It may be of interest to incorporate other explosive and technical training methods (e.g., straight sprints) to optimize COD adaptations.

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