EFFECTS OF COMBINED STRENGTH AND POWER TRAINING ON PHYSICAL PERFORMANCE AND INTER-LIMB ASYMMETRIES IN ADOLESCENT FEMALE SOCCER PLAYERS

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Abstract

Purpose: This study examined the effects of an 8-week combined strength and power training (CSPT) intervention on physical performance and inter-limb asymmetries in adolescent female soccer players. **Methods:** Thirty-seven adolescent female soccer players (age: 16.1±1.1 yrs) were randomly assigned to a control (CG, n = 18) and experimental group (EG, n = 19). EG performed CSPT twice a week, which consisted of strength and power exercises that trained the major muscles of the lower body and trunk musculature. Pre- and post-intervention tests included unilateral and bilateral horizontal and countermovement jump tests, a 40-m sprint test (10 and 30-m split times), a 10-m sprint with a 180º change of direction (COD) test and a multiple COD test (V-cut test). Asymmetries were also analyzed in the unilateral tests. **Results:** Significant group by time interaction of the improvement between pre and post-tests were observed for speed (Effect size (ES): -1.30 to -1.16) and COD tests (ES: -0.62 to -0.61) but not in jumping (ES: -0.09 to 0.28) and inter-limb asymmetries tests (ES: -0.13 to 0.57). **Conclusions:** The short-term in-season CSPT program induced greater speed and COD performance improvements compared to soccer training alone in adolescent female soccer players.

Keywords: strength, change of direction, intervention, football, female

Introduction

Soccer is considered a contact sport, demanding a wide variety of skills at different intensities. In this regard, soccer players predominately run throughout the game, while other high intensity activities like sprinting, jumping, kicking and changing direction are also important performance factors that require both maximal strength and anaerobic power of the neuromuscular system [1,2]. Given the importance of high intensity activities for soccer performance, training strategies that ensure their optimal development are continuously being investigated and also, in recent years is having a great importance in youth soccer players [3,4].

In order to design an appropriate training program, it is important to consider both the players´ age, stage of biological maturation, and their movement competence. The aim of training before peak height velocity (PHV) should be to increase neuromuscular strength, fundamental movement skills, and speed [5]. Players circa-PHV could suffer a reduction in coordination and joint range of motion, whilst concurrently experiencing increases in physiological stress during match play [6]. Finally, research highlights that post-pubertal players should prioritise improvements in strength and power, due to the natural increase in lean muscle mass associated with maturation [7]. Therefore, training programs in youth female soccer players should take into consideration the athlete's physical capability (fundamental movement skills and soccer specific fitness), biological maturation, individual needs, and acute readiness to train [8].

Different training methods to improve soccer specific variables have been developed such as, high-intensity interval training, resisted sprint training, strength training or plyometric training [9-13]. A previous study of female college soccer players showed that high-intensity interval training, performed twice per week for 5-weeks, significantly improved the Yo-Yo Intermittent Recovery 1 test distance (Effect size (ES):

0.44) [11]. Shalfawi et al. [12] compared the effects of resisted agility and resisted sprint training with strength training on highly-trained (e.g., second division standard in Norway, top 3 in this division at the time of the study and 4-7 training sessions a week) female soccer players. They reported that 10-weeks of resisted sprint training (performed twice per week) improved maximal oxygen uptake during the incremental 20-m beep-test (ES: 0.85) and the squat jump (SJ) (ES: 0.42), while strength training significantly increased the beep-test performance (ES: 0.92) and the SJ (ES: 0.59). Ramirez-Campillo et al. [10] developed a 6-week plyometric training program with 38 female soccer players. They registered vertical jump height (ES: 0.48), speed (ES: 0.86) and change of direction time (ES: 0.85) improvements in comparison to the control group. Whilst individual training interventions have been shown to produce enhancements in measures of athletic performance for soccer players [9,11,14,15], there is a lack of studies looking at the effectiveness of strength and power training specifically on performance measures in youth female soccer populations.

Inter-limb asymmetries have been a common source of investigation in recent years and refers to the concept of comparing the function of one limb in respect to the other [16]. Between-limb imbalance in strength and power, assessed as the limb symmetry index, has been considered as a valid and useful tool to detect players at high injury risk (e.g., 4-fold in players with >10% asymmetry) of lower extremity injury [17]. Additionally, inter-limb asymmetries might also play a role in performance (e.g., greater symmetrical team-sports players seem to be faster that their asymmetrical counterparts) [18,19]. In this regard, strength training is amongst the most frequently used strategies to improve soccer performance and high-intensity actions, as well as to decrease asymmetries [12,14,20-22]. Therefore, training programs should focus on combined bilateral and unilateral strength training to decrease inter-limb asymmetries and to increase performance during competition. However, relatively few studies have addressed this issue in young soccer players [22,23]. In addition, to the authors´ knowledge, no studies have analyzed the effect of an intervention on inter-limb asymmetry in youth female soccer players, hence, more studies for this population are warranted.

Therefore, the aims of the present study were 1) to evaluate the effects of combined strength and power training (CSPT) in physical performance and, 2) to observe if inter-limb asymmetries decreased as a result of the training intervention 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.

Methods

Subjects

A total of 37 adolescent female soccer players (age: 16.1 ± 1.1 yrs; height: 159.7 ± 7.1 cm; body mass: 55 ± 7.1 kg) belonging to the same female soccer division club academy squad (Iberdrola Women´s First Division) participated in this study. Their maturational status was assessed through age at PHV [24], but validation studies indicated several limitations in this equation such as the lack of a measurement of sitting height and a typical error of measurement of 0.5 years [25,26]. Data collection took place during the sixth month out of nine during the competitive season. All players were training in a soccer club for at least 4 years. None of the players had any background in regular strength and power training. At the time of the study, all players were competing at national and regional standard (e.g., Spanish Female Soccer National League, Aragón Female Football Territorial League). Furthermore, some players (n = 4) were also competing at international standard (e.g., European Female Soccer Championship). Participants were healthy and they did not suffer any disease or injury that could affect the results of the study. Written informed consent was obtained from both the players and their parents before beginning the investigation. 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).

Study Design

Using a pre-test matched-pairs study design (ABBA distribution), players from two different teams were divided into an experimental group (EG: $n = 19$) and a control group (CG: $n = 18$) based on their change of direction speed performance. Players were classified using a points system across all change of direction speed tests, from the first to the last position. Thereafter, each player was positioned in a global classification. From this point, the first player, that is, the player who had the most points was allocated in the experimental group, the 2nd and the 3rd players were allocated into the control group, and the 4th player in the experimental group. Both teams were involved in a similar weekly soccer training volume and methodology (3 sessions/week of 90 minutes and 1 match/week). EG players carried out an additional CSPT program twice per week for 8-weeks after the habitual warm-up. Players in the CG performed their habitual training that consisted on 15-min warm-up, 30-min technical training, 30-min tactical training, 40-min small-sided games and 5-min cool-down. Both groups performed the same training volume on the pitch. Tests were performed 2 weeks and 1 week (reliability analysis) before training and 1 week after the training period. Furthermore, 2 weeks before the commencement of intervention, four familiarization sessions were executed in the EG to thoroughly learn the exercises included in the CSPT program (Figure 1). The same researchers supervised every training session.

***** Figure 1 about here *****

Procedures

Combined Strength and Power Training Program.

The CSPT was completed during the mid-portion of the competition period. The EG performed 2 sessions (~35 minutes) per week at the same time interspersed by 48-72 hours during an 8-week period. Table 2 shows in detail the characteristics the training program. Exercises were performed in the same order in which they appear in the table (e.g. in session 2, training exercises were performed in the following order: diver, forward lunge, backward lunge, plank and lumbar bridge), and all exercises repetitions had to be completed before the following training set. Approximately 3-min rest periods were allowed between each set and each exercise. Box to single-leg box step up and eccentric box drops had a 30 cm height. All exercises were body weight resistance with the exception of the diver, forward lunge and backward lunge exercises. In all sessions, the warm up consisted of 5 minutes jogging and 5 minutes of joint mobilization exercises. Then, participants performed once set of 6-10 repetitions followed by once set of 6-10 repetitions (separated by 3-min rests) of 5-6 exercises in each session. Two experienced S&C coaches controlled every training session, providing verbal encouragement to each participant.

***** Table 2 about here *****

Performance Tests

Participants were assessed at baseline and 8 weeks post-intervention on jumping, linear sprinting and CODA tests by the same group of investigators during the entire study, at the same time of the day (18:00-20:00) and under the same environmental conditions

(~22ºC and ~20% of humidity) on a soccer field. Performance tests were completed in 2 hours on the soccer field. Before all testing, a warm-up standardized during 10 minutes was completed by participants. This consisted of running at 60-70% of the maximum heart rate, dynamic stretches such as multi-planar lunges, inchworms and spiderman exercises before progressing into practice jumps, sprints and change of directions at 60, 80 and 100% of perceived maximum effort. A 3-minute rest was prescribed between the warm-up and the first test. Players wore athletic shoes (for jump tests) and soccer boots (for linear sprint and COD tests).

Standing broad jump test

The standing broad jump test 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 [27]. Each test was performed three times, separated by at least 30 seconds of passive recovery, and the best jump was recorded and used for analysis.

Single-leg horizontal jump test

The single-leg horizontal jump test 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 [28]. Leg swing of the alternate leg flexed to 90º at the hip and knee was allowed. The variables used in analyzes were: 1-legged left horizontal jump and 1-legged right horizontal jump. Each test was performed three times, separated by at least 30 seconds of passive recovery, and the best jump was recorded and used for analysis.

Bilateral and unilateral countermovement jump test

Vertical jumping ability was assessed using a vertical countermovement (CMJ) jump test (reported in centimeters) with flight time measured by the Optojump

(*Optojump, Microgate, Bolzano, Italy*) to calculate jump height and is described elsewhere [28]. Each test was performed three times, separated by 30 seconds of passive recovery, and the best jump was recorded and used for analysis. The same criterion was used to assess unilateral CMJ test. Leg swing of the alternate leg flexed to 90º at the hip and knee was allowed. Furthermore, subjects were instructed to perform a controlled, balanced landing and to stick the landing for 2-3 s with the same assessed leg.

40-m speed test

Running speed was evaluated by a 40-m sprint time (standing start) with 10-m, 20-m, 30-m split times. Time was recorded with dual beam photocell systems (*Witty, Microgate, Bolzano, Italy*) and is described elsewhere [28]. The 40-m sprint was performed twice, separated by at least three minutes of passive recovery. The best time was recorded for analysis.

180º Change of direction test.

Players performed a 10-m sprint test with one 180º COD. Sprint times were measured by dual beam photocell systems (*Microgate, Bolzano, Italy*) a 10-m sprint test was performed and is described elsewhere [28]. The 180º COD was repeated twice with right and left and 2-min of between-repetitions recovery was allowed. The best time with each 180º COD was retained.

V-cut test

Players performed a 25-m sprint with four CODs of 45º 5 m each and is described elsewhere [28]. 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 recorded for analysis

Statistical Analysis

Statistical analysis was 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 significant was inferred from $p < 0.05$. Relative reliability analysis was examined by the intra-class correlation coefficient ($ICC_{3,1}$). To examine the absolute reliability, the typical error of measurement was used. The spreadsheet of Hopkins (Reliability from consecutive pair of trials, xrely.xls (2015)) was used to determine both ICC and typical error of measurement, expressed as a coefficient of variation. A repeated measures ANOVA with Bonferroni post-hoc analysis was conducted to determine systematic bias between time points, with an alpha level of $p <$ 0.05. Within-group comparisons (Student paired *t*-test) were carried out to detect significant differences between the pre-test and post-test in all variable in both groups. In addition, an ANCOVA (general linear model) was used to detect any significant between-group difference at post-test using the pre-test as covariates. The standardized difference or effect size (ES, 90% confidence limit) in the selected variables were calculated using the pre-training SD. Threshold values for Cohen ES statistics were >0.2 (small), >0.6 (moderate), and >1.2 (large) [29].

Inter-limb asymmetry was calculated using the following formula [30]:

Inter-limb asymmetry = 100/Max Value (right and left)*Min Value (right and left)*-1+100.

Results

Only players who participated in 85% of the training sessions were included in the final analyses. No participant was excluded due to injury, illness or lack of interest, and as a result, all players were included in the final analyses. No significant between-group differences were found at pre-test for any of the variables analysed. Reliability of all tests performed in CG and EG is shown in Table 3.

***** Table 3 about here *****

Performances in jump, linear sprinting and change of direction tests are shown in Table 4. No significant group by time interaction of the improvement between pre and post-tests were observed for jump and inter-limb asymmetries tests. ANCOVA showed significant group by time interactions for the 20-m (p = 0.01; ES: 1.30 (90% confidence limit [CL]: 0.87; 1.73)), 30-m (p = 0.01; ES: 1.20 (90%CL: 0.82; 1.57)), 40-m (p = 0.01; ES: 1.16 (90%CL: 0.85; 1.47)), the left 180º COD (p = 0.03; ES: 0.61 (90%CL: 0.20; 1.03)) and the V-cut test (p = 0.01; ES: 0.62 (90%CL: 0.20; 1.05)) in favour of the EG

***** Table 4 about here *****

Discussion

The aims of the present study were to evaluate the effects of a CSPT program on physical performance and to examine such effects on inter-limb asymmetries in several unilateral tests, in a group of adolescent female soccer players. The main finding of this study was that a CSPT induced improvements in speed and change of direction parameters in adolescent female soccer players but, did not improve jump and asymmetry parameters. Therefore, these results provide relevant evidence to support the need for adding strength and power training within the soccer training program to obtain further development of the speed and change of direction performance of adolescent female soccer players.

The between group analyses did not show significant differences in any jump variables at post-testing, which was in agreement with the previous studies on adolescent soccer players using strength training [12,31]. However, other studies have shown improvements in jump ability after similar training programmes have been performed [10,32,33]. These previous studies have all programmed exercises where the speed of movements are performed at high velocity. In contrast, the current CSPT program seems to have been less effective in making positive during jump testing, than other programs using explosive plyometric and strength exercises. These results suggest that the speed of movement (rather than the resistance of load) is more likely to positively affect jump performance in adolescent female soccer players.

The CSPT approach employed in the present study was an effective training strategy to enhance sprinting and change of direction performance. A recent study with similar training methods also reported significant changes in these physical qualities, in female soccer players [34]. This study speculated that strength and power training was important in developing sprint physical qualities but could not prove this within the limitations of a single-arm quasi-experimental design. In contrast, the present study used both a CG and EG, and showed that the selected exercises were effective at improving sprint and change of direction performance (ES: -0.61 to -1.30). According to this study, it is appears that strength and power training may be consistent training methods to drive the neuromuscular adaptations (e.g. increase in neural drive, coordination or improved fundamental movement skills) that likely improving acceleration, deceleration, peak velocity and/or change of direction speed.

Regarding sprint time, the training program resulted in significant 20-m, 30-m and 40-m improvements for EG compared to CG. Given the inherent differences often employed between study methodologies, true comparisons between different studies is challenging. However, others studies have found similar significant increases in sprint performance after a plyometric program in female soccer players [10,35]. It is well acknowledged that horizontal force production has an important application in sprint acceleration performance [36]. Both plyometric training discussed previously and the current training program incorporated horizontal stimulus and this may have increased the chances to gain adaptations. However, Shalwafi et al. [12] have shown that during the in-season period and after a strength program, female soccer players did not improve sprint performance. It has been observed that soccer players experience a reduction in performance during the competitive period [37] and strength training should be used with caution during mid-season. Findings of the present study suggest that CSPT was effective in improving acceleration (e.g., 20-m sprint-time) performance after 8-weeks of training (Table 3). It should be noted that a meaningful portion of the CSPT exercises (e.g., eccentric box drops, forward and backward lunges and single-leg box step up) in the current intervention have been shown improve muscular power in the hip, knee and ankle extension, which are highly related to short-distance sprints [38,39]. Hence, these results highlight the importance of developing both lower body strength and power which may enhance linear sprinting performance [40]. Further research is warranted to observe what exercise order and training scheduling is better to improve linear sprinting performance in adolescent female soccer players.

Current results indicated significant improvements in change of direction performance after the CSPT program. Our findings and others [34,41] have observed significant improvements in change of direction ability in adolescent female soccer players. It has been described that to achieve the fastest performance during a change of direction test; larger contributions of isometric and eccentric strength, higher braking and propulsive forces and lower contact times, are all required [42]. The utilization of different exercises such as forward and backward lunges, Russian belt posterior and anterior chain, and single-leg box step ups may have induced higher isometric contractions; thus, facilitating improved technique and body alignment during change of direction tests. The isometric strength seems to be decisive to optimize the triple extension during 180º COD test, as a result of permitting the correct alignment of the lower limbs to then subsequently, reaccelerate thereafter [42]. Thus, the CSPT intervention was again, effective at improving key movement patterns (180º directional change) which are common movements in soccer.

Despite the apparent critical relevance of between-limb imbalance for protection against injury and performance [17,18], to the best of our knowledge, this is one of the first study to assess the impact of a training intervention on lower- extremity asymmetries in adolescent female soccer players [4]. Nevertheless, the current CSPT program did not make any meaningful changes in inter-limb asymmetries. Pardos-Mainer et al. [4] reported that a neuromuscular training program was effective at reducing the drop jump (ES: 0.72) and change of direction (ES: 0.93) asymmetries. When viewing the asymmetry results in Table 4, it is evident that the SD is quite large relative to the mean value; more so than for other test metrics. In turn, this may be a reason as to why no significant differences in asymmetry were present post-intervention. Furthermore, practitioners should be somewhat mindful of assessing relationships between an asymmetry index and additional fitness test scores. Asymmetry is a ratio (i.e., made up of two composite parts); thus, it is probable that biased or inflated correlations may be reported when the relationship between asymmetry and its composite parts are assessed. Thus, it is suggested that practitioners consider interpreting changes in asymmetry rather than associative analysis, and on an individual basis, which is in line with recent empirical suggestions on the topic [43].

In addition, a previous study evaluated the effect of three different unilateral strength training strategies in young soccer players [44]. Interestingly, all training strategies decreased CMJ asymmetry (ES: 0.08 to 0.23) but did not decrease single-leg horizontal jump asymmetry (ES: -0.58 to 0.06). Thus, it is not currently clear what the best training strategy is to decrease between-limb differences.

A possible limitation of the present study is that exercise intensity (e.g., session rating of perceived exertion) was not measured. The use of such a non-invasive method to quantify the internal training load in each training session could be useful in future study designs. Second, analysis asymmetry was calculated using the group mean value, which showed the variable nature of asymmetry, as represented by the large SD. As previously suggested, it is suggested that monitoring changes in asymmetry is done on an individual basis. In addition, in order to determine whether a change in asymmetry is meaningful, it is suggested that this change must be greater than the test variability score [43,45], which is in line with recent suggestions on the topic. Furthermore, adolescent female soccer players have particular characteristics and, our results cannot be directly extrapolated to other sports. In this way, we cannot establish the influence of maturation through PHV as all players are substantially above PHV. Consequently, further studies should be done taking into account maturity offset (i.e., with pre-, mid- and post-PHV) to determine the possible influence of maturation on performance adaptations. Finally, to try to achieve similar results in a similar sample a proper execution is required to develop the expecting adaptations and, in consequence, experienced coaches should be involved.

Conclusions

For our adolescent female soccer players, the addition of strength and power training in the short-term (i.e., 8 weeks) during the in-season period, induced greater speed and change of direction performance improvements compared to soccer training alone. However, inter-limb asymmetries did not decrease; thus, it should be interesting to incorporate other training methods (e.g., plyometric training) or strategies (e.g., start the session with the weaker leg) to minimize injury risk and to improve performance.

Practical applications

The findings of this study are that a CSPT during the in-season period in adolescent female soccer players can improve speed and change of direction performance. These adaptations can be achieved in a few weeks and may potentially increase competitive performance and minimize the risk of injury. It is worth noting that simple interventions can produce significant improvements in an adolescent population that is relatively untrained in strength and power. Therefore, our data support the notion that strength and power training can elicit sprint related performance improvements in-season.

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Figure 1. Exercises of combined strength and power training program.

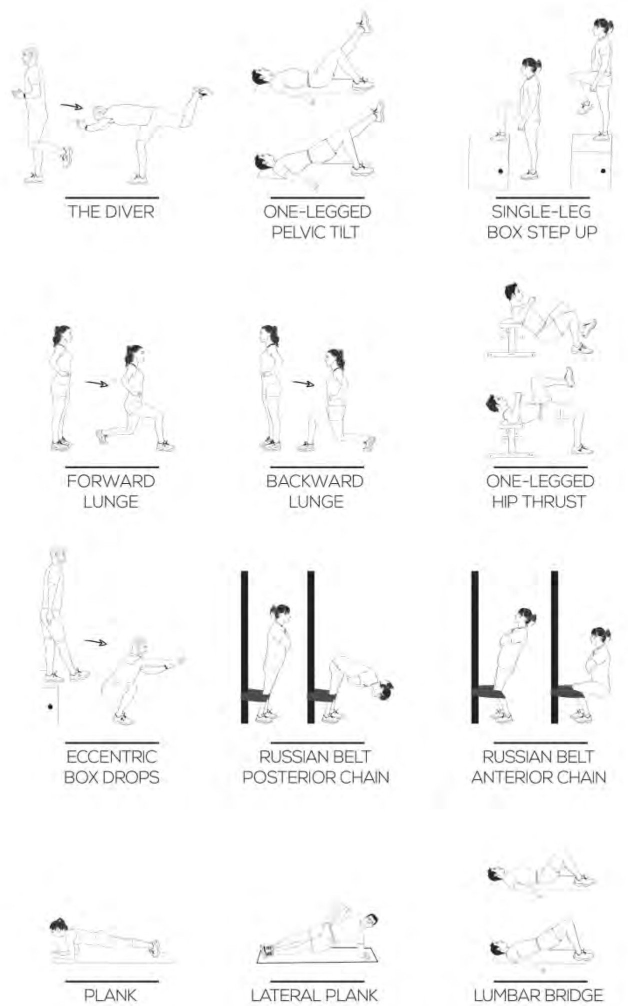

Figure 1

210x297mm (300 x 300 DPI)

Table 1. Descriptive Data of the Participants. Mean ± SD.

	Age (y)	APHV	Height (cm)	Body mass (kg)	BMI (kg/m^2)
Experimental group	16.2 ± 0.9	2.87 ± 0.49	159.8 ± 5.4	55.9 ± 5.5	21.8 ± 2.1
Control group	15.6 ± 0.9	2.34 ± 0.62	159.7 ± 4.9	54.1 ± 8.8	21.2 ± 2.9

BMI: Body- mass index; APHV: Age at peak height velocity;

Table 2. Combined strength and power training program*

Exercise	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8	
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
The Diver		6R		6R		2 8R		8R		6R (10% BM)		6R (10% BM)		8R (10% BM)		8R (10% BM)
One-legged pelvic tilt	6R		6R													
Single-leg box step up							6R		6R		8R		8R		10R	
Forward lunge		6R		6R		8R		8R		6R (10% BM)		6R (10% BM)		8R (10% BM)		8R (10% BM)
Backward lunge		6R		6R		8R		8R		6R (10% BM)		6R (10% BM)		8R (10% BM)		8R (10% BM)
One-legged hip thrust					6R		6R		8R		8R		10R		10R	
Eccentric box drops								6R		6R		8R		8R		10R
Russian Belt posterior chain	6R		6R		7R		7R		8R		8R		10R		10R	
Russian Belt anterior chain	6R		6R		7R		7R		8R		8R		10R		10R	
Plank	15s	15s	15s	15s	15s	15s	15s	20s	20s	20s	20s	20s	20s	20s	20s	20s
Lateral plank	15s		15s		15s		15s		20s		20s		20s		20s	
Lumbar bridge		15s		15s		15s		20s		20s		20		20s		20s

* All exercises were repeated 2 sets; Recovery between sets = 3 minutes; R: Reps; BM: Body mass

Table 3. Reliability data for each test (n= 37).

	p	ICC (CL90%)	CV (CL90%)
CMJ	0.70	0.89 (0.80; 0.93)	6% (4.9; 8)
CMJ_R	0.25	0.93 (0.87; 0,97)	3% (2.5; 4.1)
CMJ_L	0.98	0.91 (0.77; 0.95)	4.8% (4; 6.3)
SBJ	0.80	0.91 (0.77; 0.96)	1.8% (1.4; 2.6)
SLH_R	0.82	0.85 (0.71; 0.92)	4.3% (3.5; 5.3)
SLH_L	0.58	0.80 (0.58; 0,93)	5.5% (4.5; 6.8)
10m	0.01	0.82 (0.58; 0.92)	4.2% (3.5; 5.4)
20m	0.01	0.85 (0.65; 0,94)	3.6% (2.4; 7.5)
30m	0.01	0.88 (0.81; 0.93)	2.2% (1.7; 3.3)
40m	0.01	0.89 (0.76; 0.90)	2.3% (1.8; 3.3)
180ºCOD_R	0.51	0.85 (0.71; 0.92)	2.5% (1.9; 3.5)
180ºCOD_L	0.59	0.86 (0.65; 0.93)	2.4% (1.6; 4.2)
V-cut	0.34	0.80 (0.57; 0.93)	2.5% (1.6; 3.6)

ICC: Intra-class correlation coefficient; CV: Coefficient of variation; R: Right; L: Left; SBJ: Standing broad jump; SLH_R: one-legged horizontal right jump; SLH_L: one-legged horizontal left jump; CMJ: countermovement jump; CMJ_R: one-legged vertical right jump; CMJ_L: one-legged vertical left jump; 180ºCOD: 5+5 m sprint test with a 180º change of direction; R: right; L: left; V-cut: 25-m sprint test with 4 x 45º changes of direction.

Table 4. Summary results of all tests performed in Control Group and Experimental Group. Mean ± SD

	Control Group				**Experimental Group**				**Interaction** #	
Variable	**Pre-test**	**Post-test**	**p**	**ES (90 CL)**	**Pre-test**	**Post-test**	**p**	**ES (90 CL)**	**p**	**ES (90 CL)**
SBJ (m)	1.41 ± 0.18	1.46 ± 0.20	0.12	0.22 (-0.02; 0.46)	1.74 ± 0.15	1.78 ± 0.16*	0.01	0.29 (0.12; 0.46)	0.70	-0.03 (-0.26; 0.20)
SLH_R (m)	1.20 ± 0.14	1.25 ± 0.14*	0.01	0.32 (0.17; 0.47)	1.32 ± 0.15	1.37 ± 0.19	0.09	0.25 (-0.14; 0.54)	0.88	-0.09 (-0.37; 0.20)
SLH_L (m)	1.25 ± 0.13	1.28 ± 0.14	0.10	0.22 (0; 0.44)	1.29 ± 0.11	1.36 ± 0.16*	0.01	0.58 (0.24; 0.92)	0.18	0.28 (-0.07; 0.63)
% As SLH	4.09 ± 3.93	4.48 ± 3.33	0.64	0.07 (-0.33; 0.47)	6.32 ± 5.41	5.26 ± 5.08	0.43	-0.26 (-0.85; 0.33)	0.78	-0.13 (-0.67; 0.41)
CMJ (cm)	23 ± 3.73	23.9 ± 4.35	0.22	0.23 (-0.10; 0.57)	23.5 ± 3.30	25.6 ± 3.65*	0.01	0.55 (0.25; 0.85)	0.24	0.28 (-0.16; 0.71)
CMJ_R (cm)	12.1 ± 2.77	13.1 ± 2.65	0.06	0.36 (0.07; 0.66)	12.9 ± 1.95	14.3 ± 2.44*	0.02	0.58 (0.18; 0.98)	0.53	0 (-0.47; 0.46)
CMJ_L (cm)	11.7 ± 2.36	12.8 ± 3.16	0.09	0.40 (-0.03; 0.83)	12.9 ± 3.1	13.9 ± 3.1	0.08	0.31 (-0.02; 0.63)	0.84	-0.01 (-0.51; 0.50)
% As UCMJ	12.5 ± 10.2	15.7 ± 10.1	0.29	0.22 (-0.23; 0.67)	11.5 ± 8.99	11.5 ± 11.3	0.97	-0.21 (-0.77; 0.35)	0.34	-0.04 (-0.70; 0,61)
10m (s)	2.1 ± 0.11	1.99 ± 0.10*	0.01	-0.98 (-1.55; -0.41)	2.08 ± 0.07	1.99 ± 0.09*	0.01	-1.29 (-1.99; -0.59)	0.98	0.16 (-0.66; 0.98)
20m (s)	3.42 ± 0.10	3.46 ± 0.14	0.12	0.33 (-0.04; 0.69)	3.6 ± 0.12	3.45 ± 0.13*	0.01	-1.21 (-1.60; -0.83)	0.01#	-1.30 (1.73; 0.87)
30m (s)	4.81 ± 0.15	4.85 ± 0.19	0.15	0.23 (-0.05; 0.42)	5.05 ± 0.18	4.85 ± 0.19*	0.01	-1.11 (-1.45; -0.76)	0.01#	-1.20 (1.57; -0.82)
40m (s)	6.24 ± 0.21	6.29 ± 0.25	0.17	0.19 (-0.05; 0.42)	6.51 ± 0.26	6.24 ± 0.25*	0.01	-1.02 (-1.27; -0.77)	0.01#	-1.16 (-1.47; -0.85)
$180ºCOD_R$ (s)	2.89 ± 0.11	2.93 ± 0.12	0.58	0.23 (-0.14; 0.60)	2.87 ± 0.16	2.85 ± 0.18	0.44	-0.15 (-0.49; 0.18)	0.47	-0.19 (-0.67; 0.29)
$180ºCOD_L$ (s)	2.93 ± 0.15	2.91 ± 0.11	0.86	-0.18 (-0.45: 0.09)	2.96 ± 0.16	2.89 ± 0.18*	0.03	-0.52 (-0.89; -0.14)	0.03#	-0.61 (-1.03; -0.20)
% As COD	2.62 ± 2.29	2.14 ± 1.55	0.49	-0.07 (-0.55; 0.41)	4.42 ± 3.14	2.55 ± 1.93	0.08	-0.30 (-0.96; 0.36)	0.39	-0.57 (-1.56; 0.41)
V-cut (s)	7.98 ± 0.38	7.97 ± 0.39	0.24	-0.02 (-0.26; 0.21)	8.05 ± 0.38	7.81 ± 0.27*	0.01	-0.58 (-0.90; -0.27)	0.01#	-0.62 (-1.05; -0.20)

R: Right; L: Left; CMJ: countermovement jump; UCMJ: unilateral countermovement jump; CMJ: countermovement jump; CMJ_R: one- egged vertical right jump; CMJ_L: one-legged vertical 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; 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 ($p < 0.05$)

#Significant group by time interaction including pre-test as covariate ($p < 0.05$)