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RELATIONSHIPS BETWEEN SPRINTING, AGILITY, ONE- AND TWO-LEG VERTICAL AND HORIZONTAL JUMP IN SOCCER PLAYERS

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Abstract:

The aim of this study was to profile physical characteristics of soccer players measured by acceleration, vertical jump (VJ), horizontal jump (HJ) and change of direction ability (CODA) tests, and to quantify the relationships between these characteristics. Additionally, leg asymmetries between the dominant and non-dominant legs during unilateral VJ and HJ were assessed. Thirty-nine male soccer players (22.9±2.8 years, 179.9±6.01 cm, 77.0±8.3 kg), competing in the third division of the Spanish Soccer League, participated in this study. Soccer experience of these players amounted to 15.19±3.15 years. Significant moderate correlations ($p<.05$) were found between all HJ tests and the modified agility (MAT) or the 505 test, and between all VJ tests and the Y20 or the 505 test. The significant differences between the dominant and non-dominant legs were found for the horizontal drop jump test ($p=.001$, $d=.66$) and horizontal three jump test ($p=.017$, $d=.33$). No significant differences between the dominant and non-dominant legs were found for VJ tests. The correlation between jumping and CODA varied depending on the characteristics of test types. The significant leg asymmetry in horizontal jumps with bounds found in the present study suggests that soccer players have greater leg asymmetries in the horizontal jump than in the vertical jump.

Key words: *football, sprint, agility, strength, test, correlation, leg asymmetry*

Introduction

Soccer is considered an intermittent activity involving sudden variations in movement and intensity (Stølen, Chamari, Castagna, & Wisløff, 2005). However, during a match, the duration of displacement at high velocities does not last longer than 3 seconds (Bangsbo, Norregaard, & Thorso, 1991). Despite their short duration, the response to these different and rapid movements is essential in soccer (Svensson & Drust, 2005) and the sprint performance may be considered relevant in soccer (Svensson & Drust, 2005). Soccer players do not generally achieve maximal running speeds during match-play (Delecluse, 1997). The average distance covered at high intensity by elite soccer players during competition is ~15 m (Stølen, et al., 2005), therefore, on many occasions 5, 10 or 15 m sprint tests have been used to assess the acceleration capacity (Gorostiaga, et al., 2009; Impellizzeri, Rampinini, Maffiuletti, & Marcora, 2007; Los Arcos, et al., 2014).

Only in limited periods of time do soccer players make contact with the ball (Helgerud, Engen, Wisløff, & Hoff, 2001; Stølen, et al., 2005). During a soccer game, ~1,300 changes in activity are undertaken in off-the-ball conditions (Stølen, et al., 2005). Therefore, due to the relevance of change of direction ability (CODA) in soccer, the examination of its nature as well as evaluation of it can be interesting. Evaluating CODA in the absence of a 'gold standard' test in soccer (Chaouachi, et al., 2012; Svensson & Drust, 2005) has entailed the use of many different tests including: T-test (Chaouachi, et al., 2012; Sporis, Jukic, Milanovic, & Vucetic, 2010), T-test modifications (Sassi, et al., 2009), Illinois test (Raven, Gettman, Pollock, & Cooper, 1976), 5mSS test (Chaouachi et al., 2012) and Four-Line sprint (Taskin, 2008). However, the characteristics of these tests (i.e. duration, the number of direction changes, etc.) and complexity of movement variations (Brughelli, Cronin, Levin, & Chaouachi, 2008) would likely be ideal for specific CODA assessment in soccer. In this line, Chaouachi et al. (2012) determined that the 5mSS test was more soccer specific than the T-test. It has been suggested that the characteristics of CODA tests affect the magnitude of association between several athletic performance variables (Chaouachi, et al., 2012; Sheppard & Young, 2006).

Many researchers have investigated the relationship between jump capacity (vertical and horizontal direction alike) and functional performance as acceleration and CODA in many sports. However, the results are contradictory (Salaj & Markovic, 2011; Wisløff, Castagna, Helgerud, Jones, & Hoff, 2004). In fact, acceleration, bilateral jumping and CODA could be considered as independent abilities (Salaj & Markovic, 2011). Despite the importance of horizontal forces during acceleration (Kugler & Janshen, 2010; Mero, 1988) and the high correlation between unilateral horizontal jumps and acceleration (Maulder & Cronin, 2005), unilateral jumping in the horizontal and vertical directions has not been extensively investigated in soccer players (Ronnestad, Kvamme, Sunde, & Raastad, 2008). Despite the requirement of a unilateral propulsion either in vertical or horizontal direction imposed by many activities (Maulder & Cronin, 2005) such as soccer, and the differences between contra lateral legs that occur during functional tests, presenting an injury risk or obstacle for return to sport (Croisier, Ganteaume, Binet, Genty, & Ferret, 2008), there is little information on unilateral jumping performance in soccer players.

The aims of the present study were to profile physical characteristics of soccer players measured by the tests of acceleration (5, 10 and 15 m sprints), vertical jump (VJ), horizontal jump (HJ) and change of direction ability (CODA), and to quantify the relationships between these characteristics. Additionally, leg asymmetries between the dominant and non-dominant leg during unilateral vertical and horizontal jumping were assessed.

Methods

Participants

Thirty-nine male soccer players (22.9±2.8 years, 179.9±6.01 cm, 77.0±8.3 kg), competing in the third division of the Spanish Soccer League, participated in this study. The participants had soccer experience of 15.19±3.15 years. All players had participated in their regular endurance, sprint and specific soccer training programme of 3-4 days per week for more than six years. Written informed consent was obtained from each soccer player after a detailed written and oral explanation of the potential risks and benefits resulting from their participation in the experiment. The players had an option to voluntarily withdraw from the study at any time. Also, the study was conducted with the consent of the club to which they belonged and according to the Declaration of Helsinki (2008), and was approved by the local ethics committee.

Procedure

In this study, we examined the relationship between sprinting, CODA and jumping abilities in soccer players. Additionally, leg asymmetries between the dominant and non-dominant leg during unilateral vertical and horizontal jumping were assessed. The physical performance was determined by testing the qualities usually evaluated in soccer players (Gorostiaga, et al., 2009; Impellizzeri, et al., 2007; Los Arcos, et al., 2014). The first evaluation session consisted of acceleration (5, 10 and 15 m sprints) and CODA tests measured by the modified agility test (MAT), 505 agility test (505) and 20 yards agility test (20Y). The second evaluation session consisted of the vertical (VJ) and horizontal jump (HJ) tests, both unilateral and bilateral.

The tests were carried out during a competitive season and all soccer players were required to attend the exercise-testing laboratory on two separate occasions. On the first visit, a familiarization, information session, the anthropometrics, acceleration and change of direction ability (CODA) measures were taken. After seven days, the subjects returned to the laboratory for the second testing sessions, consisting of vertical and horizontal jump test (VJ and HJ, respectively). They were also told not to perform any strenuous exercise 48 hours before the testing. Before each testing session a standardized warm-up protocol was performed which consisted of a five-minute self-paced low-intensity run, of skipping exercises, strides, two 15 m sprints with and without changes of direction, two vertical and horizontal jumps. During the testing sessions, the air temperature ranged from 22 to 26ºC and all testing sessions were conducted at the same time of the day (17:00-19:00) on an indoor track.

Performance tests

Acceleration test: Each soccer player performed an acceleration test consisting of three maximal sprints over 15 m, with a 120-second rest period between each sprint, thus having enough time to walk back to the start and wait for another turn as previously described by Gorostiaga et al. (2009) and Los Arcos et al. (2014). The soccer players were placed 0.5 m away from the starting point, and began the test when they felt ready (Gorostiaga, et al., 2009; Los Arcos, et al., 2014). Time was recorded using photocell gates (Microgate® Polifemo, Bolzano, Italy) placed 0.4 m above the ground (Los Arcos, et al., 2014), with an accuracy of ±0.001 s. The timer was activated automatically as the volunteers passed through the first gate at the 0.0 m mark and split times were then recorded as 5, 10 and 15 m sprints.

Change of direction ability (CODA). Modified agility test (MAT): The soccer players began with both feet together 0.5 m away from cone A, and completed the protocol according to Sassi et al. (2009). The players performed the test using the same directives, but they were not required to move laterally or face forward. The players had to touch the top of the cone instead of its base. A-B displacement (5 m): At his own discretion, each subject sprinted forward to cone B and touched the top of the cone with the right hand. B-C displacement (2.5 m): Facing forward the participant shuffled to the left to cone C and touched the top of the cone with the left hand. C-D displacement (5 m): The soccer player then shuffled to the right to cone D and touched its top. D-B displacement (2.5 m): The participant shuffled back to the left to cone B and touched its top. B-A displacement (5 m): Finally, the soccer player moved as quickly as possible and returned to line A. All participants performed the test three times with at least three minutes of rest between the trials. The total distance covered was 20 m, and the height of the cones was 0.3 m. A photocell gate (Powertimer, Newtest® Oy, Oulu, Finland), located above cone A, was used to record the time. Time measurement started and finished when the subject crossed the line between the tripods. The calculated margin of error was ±0.001 s and the sensors were set approximately 0.40 m above the floor.

505 agility test (505): The athlete sprinted forward to a line 5 m ahead and pivoted 180º before returning to the start position (Sheppard & Young, 2006). A photocell gate (Powertimer, Newtest® Oy, Oulu, Finland), located above the start/finish line, was used to record the time. Time measurement started and finished when the subject crossed the line between the tripods. The calculated margin of error was ±0.001 s, and the sensors were set approximately 0.40 m above the floor. The test has been used for other sports requiring change of directions and agility as well (Sheppard & Young, 2006).

20 yard agility test: Y20 requires ability in players to accelerate, decelerate, and change the direction by rotating the body for 180º. On an indoor surface, a 2-ft piece of tape was placed to mark the centerline. From the centerline, 5 yds (i.e. 4.57 m) were measured in both directions, and these spots were also marked with the tape. Each subject was instructed to straddle the centerline with his feet on the line. On the given command, the subject ran toward the line of his choice and touched it with his foot, changed the moving direction and ran past the centerline to the opposite line and touched it with his foot. The subject again changed the moving direction by pivoting and ran through the centerline. The drill was over when the subject crossed the centerline with his body (Salaj & Markovic, 2011). A photocell gate (Powertimer, Newtest® Oy, Oulu, Finland) placed on the start/finish line was used to record the time.

Vertical jump (VJ) tests: Soccer players' vertical squat jumps (VSJ), countermovement jumps (VCMJ), dominant leg countermovement jumps (VCMJD), non-dominant countermovement jumps (VCMJND), arm swing countermovement jumps (VCMJAS), 20 cm drop jumps (VDJ), dominant leg drop jumps (VDJD), non-dominant leg drop jumps (VDJND) and arm swing 20 cm drop jumps (VDJAS) were tested using the Opto Jump Next, Microgate, Italy, according to the procedures proposed by Maulder and Cronin (2005). The soccer players performed three jumps of each type of jump test. In all jumps (except arm swing jumps) the hands were placed on the hips during the take-off, flight, and landing phases. The maximal flexion of the knees during the take-off phase was required to be approximately ~90° (Bosco & Komi, 1978). During all jumps, a minimal flexion of the trunk during take-off was permitted (Bosco & Komi, 1978). Recovery time between jumps was 20 seconds. Any jump that did not meet the considered requirements was excluded from calculations and repeated.

Horizontal jump (HJ) tests: According to the procedures proposed by Maulder and Cronin (2005), soccer players' horizontal countermovement jumps (HCMJ), dominant leg countermovement jumps (HCMJD), non-dominant leg countermovement jumps (HCMJND), arm swing countermovement jumps (HCMJAS), 20 cm dominant leg drop jumps (HDJD), non-dominant leg drop jumps (HDJND), dominant leg 3 jumps (H3JD), non-dominant leg 3 jumps (H3JND) and 4-bounce test (H4BT) (Ronnestad, et al., 2008) were tested. Soccer players performed three jumps of each type of jump test and the recovery time between each type of jump was four minutes.

Statistical analysis

The results are presented as mean (M) ± standard deviation (SD). All the variables were normally distributed and satisfied the equality of variances according to the Shapiro-Wilk and Levene tests, respectively. The reliability of the jump assessment procedures was calculated using coefficient of variation (CV). CV was calculated for all test variables to determine the stability of measurement among trials (CV = [SD/mean] x 100) (Atkinson & Nevill, 1998). Paired *t*-tests were used to determine if any significant differences existed between the dominant and non-dominant leg. Only the maximum score of each test was included in the data analysis (Wisløff, et al., 2004). Practical significance was assessed by calculating Hopkins d effect size (Hopkins, 2010). Effect sizes (d) were classified as trivial ($d<0.2$), small ($0.2<d<0.6$), moderate ($0.6<d<1.2$), large ($1.2<d<2.0$), very large ($2.0<d<4.0$), nearly perfect ($d>4.0$), and perfect (d=infinite). Pearson product-moment correlation coefficients (r) were calculated to determine the relationships among the parameters obtained from the vertical jump. The results were interpreted using the threshold values for Pearson product-moment correlation coefficients used by Salaj and Markovic (2011): low (r≤.3), moderate (.3<r≤.7), and high (r>.7). Statistical significance was set at p<.05. Data analysis was performed using the Statistical Package for Social Sciences (version 20.0 for Windows, SPSS® Inc, Chicago, IL, USA).

Results

The sprint, change of direction, and double-leg vertical and horizontal jumps test values of the soccer players are presented in Table 1. The coefficients of variation (CV) for sprint tests ranged from 1.2% to 3.3%. It can be observed from Table 1 that there was less within-trial variation associated with the horizontal jumps (CV = 1.8–3.0%) as compared to the vertical jumps (CV = 2.7–4.8%).

The mean values for both the dominant and non-dominant legs for all soccer players are presented in Table 2. The significant differences between the dominant and non-dominant legs were found in horizontal drop jump (p<.01, d=0.66) and horizontal three jump (p=.02, d=0.33). No significant differences between the dominant and non-dominant legs were found in VJ tests (VCMJ and VDJ). Mean symmetry index scores were calculated, showing very small deficits (-.63% to -4.04%) for all jump assessments. A greater CV between sides for single-leg jumps was noted in the VJ assessment (4.5%–5.9%) compared to HJ assessment (1.5%–3.8%).

The relationships between acceleration, CODA, vertical jump and horizontal jump performance can be observed in Table 3. The significant correlations (p<.05) were found between all horizontal jump tests and the MAT (r=-.40 to -.69) or the 505 test (r=-.44 to -.58), and between all vertical jump tests and the Y20 test (r=-.36 to -.52) or the 505 test (r=-.38 to -.62). The moderate correlations were found between all one-leg vertical jump tests and 505 (r=-.38 to -.49) or 20Y (r=-.36 to -.49) tests and between all one-leg horizontal jump tests and the MAT (r=-.40 to -.62) or 505 (r=-.44 to -.58) test.

Table 1. Descriptive measures of soccer players' sprint, change of direction ability, vertical jump and horizontal jump tests

Variables	Sample	±SD	CV (%)
Sprint (s)			
5 m	0.99	0.03	2.5
10 m	1.70	0.05	1.7
15 m	2.34	0.06	1.2
Change of direction ability (s)			
MAT	4.89	0.16	2.3
505	2.49	0.08	3.3
Y20	4.80	0.14	1.8
Vertical jump (cm)			
VSJ	35.58	5.20	4.8
VCMJ	40.73	4.98	2.9
VCMJAS	48.86	5.71	2.7
VDJ	39.82	4.34	2.8
VDJAS	48.85	4.79	3.4
Horizontal jump (m)			
HCMJ	1.99	0.15	1.8
HCMJAS	2.39	0.14	3.0
H4BT	9.51	0.55	1.8

Legend: CMJ = countermovement jump; CMJAS = arm swing countermovement jump; CV = coefficient of variation; DJ = drop jump; DJAS = arm swing drop jump; H = horizontal; MAT = modified agility test; SD = standard deviation; SJ = squat jump; V = vertical; Y20 = 20 yards agility test; 4BT = 4-bounce test; 505 = 505 agility test.

Table 2. One-leg vertical and horizontal jump, symmetry index and coefficient of variation (CV) results

Variables	Dominant	Non-dominant	Symmetry index (%)	p value	d
Vertical jump					
VCMJ (cm)	22.81±3.45	23.34±2.73	-2.36	NS	0.15
CV (%)	5.9	5.9			
VDJ (cm)	23.95±3.60	24.19±3.03	-0.99	NS	0.06
CV (%)	5.3	4.5			
Horizontal jump					
HCMJ (m)	1.80±.13	1.81±0.12	-0.63	NS	0.07
CV (%)	3.0	2.0			
HDJ (m)	1.77±.12	1.85±0.14**	-4.04	.001	0.66
CV (%)	1.5	3.8			
H3J (m)	6.69±.39	6.82±0.43*	-1.99	.017	0.33
CV (%)	2.2	2.4			

Legend: d = effect size; HCMJ = horizontal countermovement jump; HDJ = horizontal drop jump; H3J = horizontal three jump; VCMJ = vertical countermovement jump; VDJ = vertical drop jump; significant differences between dominant and non-dominant leg * p<.05, ** p<.01.

Table 3. Relationships between vertical or horizontal jumps and sprint or change of direction ability (CODA) performance

	Sprint 5 m	Sprint 10 m	Sprint 15 m	MAT	505	Y20
Vertical jump (cm)						
VSJ	-.20	-.23	-.32	-.25	-.53**	-.41*
VCMJ	-.29	-.39*	-.54**	-.34	-.60**	-.47*
VCMJAS	-.19	-.32	-.48**	-.41*	-.62**	-.45*
VCMJD	-.11	-.21	-.33	-.09	-.38*	-.36*
VCMJND	-.23	-.34	-.41*	-.29	-.45*	-.46*
VDJ	-.27	-.36	-.53**	-.37	-.57**	-.49**
VDJAS	-.29	-.34	-.50**	-.48*	-.60**	-.52**
VDJD	-.15	-.25	-.41*	-.28	-.45*	-.43*
VDJND	-.40*	-.46*	-.55**	-.44*	-.49*	-.49*
Horizontal jump (m)						
HCMJ	-.47**	-.44*	.50**	-.69**	-.51**	-.38*
HCMJD	-.16	-.13	-.22	-.49**	-.44*	-.32
HCMJND	-.45*	-.41*	-.47**	-.62**	-.48*	-.31
HCMJAS	-.25	-.25	-.32	-.53**	-.53**	-.29
HDJD	-.30	-.36*	-.42*	-.54**	-.47*	-.41*
HDJND	-.26	-.35	-.39*	-.59**	-.58**	-.43*
H3J D	-.23	-.27	-.36	-.40*	-.44*	-.16
H3JND	-.29	-.41*	-.52**	-.44*	-.55**	-.32
4BT	-.32	-.47*	-.55**	-.54**	-.46*	-.26

Legend: MAT = modified agility test; 505 = 505 agility test; Y20 = 20 yards agility test; SJ = squat jump; CMJ = countermovement jump; AS = arm swing; DJ = drop jump; D = dominant leg; ND = non-dominant leg; H3J = horizontal three jump; 4BT = 4-bounce test; significant correlation * p<.05, ** p<.01.

Discussion and conclusions

This study assessed acceleration, change of direction, vertical jump and horizontal jump performance as well as vertical and horizontal jump imbalances between lower extremities in soccer players. The main contribution of the present study is the characterization of the physical performance of amateur soccer players using a field test battery. To our knowledge, no scientific articles have been published to determine the unilateral vertical and horizontal jump performance in soccer players. The main findings of this study were: 1) the moderate significant correlations were found between all horizontal jump tests and the MAT or 505 test; 2) the moderate significant correlations were found between all vertical jump tests and the Y20 or 505 test; and 3) the significant differences between the dominant and non-dominant legs were found in horizontal drop jump and horizontal three jump. However, no significant differences between the dominant and non-dominant legs were found in VJ tests.

The results obtained in sprint tests for amateur soccer players were 0.99±0.03 s at 5 m, 1.70±0.05 s at 10 m, and 2.34±0.06 s at 15 m sprint (Table 2). Comparing these scores with the ones of elite or professional soccer players, we found not only better sprint times (Gorostiaga, et al., 2009; Los Arcos, et al., 2014), but also poorer results (Wisløff, et al., 2004) than in our amateur soccer players. However, the comparison should be taken with caution due to the use of different protocols and testing surfaces. The times for the CODA tests were 4.89±0.16 s, 2.49±0.08 s and 4.80±0.14 s for MAT, 505 and Y20 CODA tests, respectively. The application of many CODA tests makes the comparison with other studies difficult. To our knowledge, while the MAT test has not been used in soccer players, the Y20 test has been applied with male young students (~19 years of age) (Salaj & Markovic, 2011) and the 505 test has been tested on several occasions in soccer players (Maio-Alves, Rebelo, Abrantes, & Sampaio, 2010; Thomas, French, & Hayes, 2009). Our amateur soccer players needed more time than young elite soccer players (Maio-Alves et al., 2010), but less time than youth players (17.3±0.4 years) of a semi-professional soccer academy (Thomas et al., 2009) to complete the 505 test. For all acceleration and CODA tests the coefficients of variation (CV) did not exceed 3.3% (Table 1). These results are in agreement with other studies performed in soccer (Sporis, et al., 2010), where the CV did not exceed 5.6%.

The relationship between acceleration, jumping and CODA is still unclear, and these motor abilities can be considered independent (Salaj & Markovic, 2011). We did find correlations among several tests; however, the magnitude of the correlations found was not high (r>.7). As can be seen in Table 3, correlations between VJ and HJ were higher with 15 m sprint compared with 5 and 10 m sprint. Only moderate significant correlations between 5 m sprint and VDJND (r=-.40, p<.05), HCMJ (r=-.47, p<.01), HCMJND (r=-.45, p<.05) and between 10 m sprint and VCMJ (r=-.39, p<.05), VDJND (r=-.46, p<.05), HCMJND (r=-.41, p<.05), HDJD (r=-.36, p<.05), H3JND (r=-.41, p<.05) and 4BT (r=-.47, p<.05) were found. However, the correlation found between sprint and VJ or HJ was higher for the 15 m sprint although the most consistent correlations were found between horizontal jumps and acceleration. As Kugler and Janshen (2010) stated, the horizontal forces are important for acceleration; however, maximizing the forward propulsion requires optimal, not maximal force application.

Regarding the relationship between CODA tests and jump tests, the results varied depending on the type of CODA test and jump test. In this study, the significant correlations were found between all HJ tests and the MAT. Also, the significant correlations were found between all VJ tests and the Y20 test. The moderate correlations were found between all HJ or VJ tests and the 505 agility test. In concordance with these results, Chaouachi et al. (2012) showed that the affecting variables of CODA differ according to the test characteristics, and Brughelli et al. (2008) exposed that the differences found among studies may be due both to the populations evaluated and to the different characteristics of the tests applied. In this study we used the MAT, 20Y and 505 agility tests, as logical representatives of general and specific CODA test paradigms in soccer (Chaouachi, et al., 2012). Based on the results obtained, the HJs would be more related to the CODA generic test (MAT) and the VJs with specific agility test (20Y) in soccer. Therefore, it might be beneficial to include strength training in both the vertical and horizontal axis, as well as bilaterally and unilaterally in order to improve performance in all spectrums of CODA.

The second aim was to compare the jump assessments as to whether they differ in their ability to determine imbalances between the two lower limbs. Unilateral vertical jump performance has been widely used in the scientific literature with various sports (Impellizzeri, et al., 2007), particularly in team sports such as basketball (Schiltz, et al., 2009), soccer (Castillo-Rodríguez, Fernández-García, Chinchilla-Minguet, & Álvarez-Carnero, 2012; Menzel, et al., 2013), and in different populations (Maulder & Cronin, 2005). However, the current study is the first to analyze unilateral horizontal jump performance and the leg asymmetry differences in horizontal jumps in male soccer players. The significant differences between the dominant and non-dominant legs were found in horizontal drop jumps and in horizontal three jumps. Itoh, Kurosaka, Yoshiya, Ichihashi, and Mizuno (1998) found that healthy male subjects were significantly different in horizontal countermovement jump performance between the dominant (1.93±0.19 m) and non-dominant legs (1.84±0.18 m). No significant differences between the dominant and non-dominant legs were found in VJ tests (VCMJ and VDJ). The results are in agreement with Castillo-Rodriguez et al. (2012) who found similar vertical jump values in both legs (CMJD=19.29±3.06 cm, CMJND=19.94±3.86 cm). Similarly, Maulder and Cronin (2005) found no significant differences between the dominant and non-dominant legs in vertical jumps (VCMJ, p=.876) in healthy participants. Contrary to the current findings, Menzel et al. (2013) found differences in vertical CMJ values in Brazilian professional soccer players. These contradictory results lead us to believe that the very practice of soccer could explain the differences found between the dominant and non-dominant legs. According to the results obtained in our study, no significant concordance of bilateral asymmetries identified by vertical and horizontal jumps was found. Possible reasons for bilateral strength asymmetries might be an inadequate or incomplete rehabilitation program, specific motor demands of different sports and training methods (Menzel, et al., 2013), or bilateral differences of the agonist-antagonist ratio. For soccer players, the analysis of bilateral strength asymmetry is an important challenge to reduce the risk of injury and allow a safe return to sport (Croiser, et al., 2008; Menzel, et al., 2013). Thus, there may be a need for specific training and exercises aimed at reducing leg asymmetries in soccer players.

The relationship between acceleration, jumping ability and CODA is still unclear. The correlation between jumping ability (vertical or horizontal alike) and CODA (general or specific alike) varied depending on the characteristics of the type of tests. Therefore, if we would train for all spectrums of CODA, it may be necessary to include multidirectional (i.e. horizontal and vertical) and unilateral and bilateral exercises to strength training in soccer. These results should be taken with caution because the correlations do not imply the cause-and-effect relationship.

The analysis of bilateral strength asymmetry is an important challenge especially for male soccer players. The significant leg asymmetry in horizontal jumps with bounds (i.e. horizontal drop jump and horizontal three jumps) found in the present study supports the fact that soccer players should practice loaded unilateral jumps in the horizontal direction in order to reduce leg asymmetries. More longitudinal studies would be needed to analyze the effects of different strength training programs in unilateral (vertical and horizontal) jumping ability.

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