Original Article

Effects of inter-limb vertical jump asymmetries on physical performance in elite soccer players under 19 years old.

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Abstract:

The aim of this study was to investigate the effects of inter-limb vertical jump asymmetries in physical performance, given the large diversity of results found on this research topic. 19 elite Under-19 soccer players from a Spanish professional club performed a test battery including bilateral and unilateral countermovement jumps, bilateral and unilateral drop jumps, horizontal jumps, sprints from 10 to 30 meters, left- and right-leg change of direction sprints and the Nordic hamstring exercise. All measures were taken with an iPad device, using “My Jump 2 App”, “My Sprint app”, “Nordics App” and “COD timer App”, previously validated, on the pitch where the team usually trains. The percentage of Inter-limb jump asymmetries was 8.05 ± 6.77 for unilateral countermovement jumps and 9.70 ± 5.41 for unilateral drop jumps. Pearson’s r correlations established a relationship between larger unilateral countermovement jumps asymmetries and a decrement in horizontal jumps ($r = -0.489$; $P < 0.05$) and between the higher unilateral drop jumps asymmetries and a lesser nordic break point angle ($r = -0.579$; $P < 0.01$). However, velocity in 10, 15, 20, 25 and 30 meters, left- and right-leg change of direction, countermovement jumps and drop jumps were not affected in a statistically significant manner. These results support previous researches which have suggested that asymmetries lower than 10 % do not affect physical performance. Results could be influenced by the high level of the sample, with a high level of expertise in their sport. In conclusion, the inter-limb jump asymmetries level found in this sample of soccer players obtained a low decrease in physical performance.

KeyWords: Drop jump; countermovement jump; football; inter-limb differences; between-leg imbalance.

Introduction

The concept of inter-limb asymmetries refers to the difference in the comparative performance between both legs (Keeley et al., 2011), and has been a popular stream of investigation in recent years (Bishop, Brashill, et al., 2019).

Jump tests are considered to be an important part in training owing to their temporal efficiency and establishing similar patterns to movements of different sports disciplines. In addition, linked with another strength test, this has been used to establish inter-limb differences in physical performances (Bishop et al., 2017; Keeley et al., 2011).

However, the role of inter-limb asymmetries and their effect on physical performance is not well known, needing further research (Bishop, Turner, et al., 2018). This affirmation could be transferred to soccer, owing to finding some research where we observe positive correlations between jump asymmetries and a worse performance in physical tests, while in other studies that correlation was not found.

For example, 30 team-sport athletes, including soccer players in the sample, carried out unilateral jump tests (vertical, horizontal and lateral), change of direction (COD) tests and sprints of 5-, 10- and 20-meters. The authors did not find significant correlations between the jump inter-limb asymmetries and the performance in other fitness tests (Lockie et al., 2014).

On the other hand, 19 elite youth female players performed a single leg countermovement jump (UCMJ), single, triple, and crossover hops for distance and a 20-meters sprint test (Bishop, Read, et al., 2018). The results showed that players with larger asymmetries between both legs in the UCMJ test achieved slower sprint times ($r = 0.49 - 0.59$).

In the same line, 16 adult female soccer players did UCMJ, unilateral drop jumps (UDJ), sprints of 10- and 30-meters and a COD speed test. Significant correlations were found between the asymmetries in inter-limb UDJ and a worse performance in the COD test ($r = 0.52 - 0.66$; $p < 0.05$), the 10- ($r = 0.52$; $p < 0.05$) and 30-meters ($r = 0.58$; $p < 0.05$) sprint times. However, inter-limb asymmetries in UCMJ did not affect the performance in the other tests (Bishop, Turner, et al., 2019).

Lastly, the research stands out as having a large sample size (Bishop, Brashill, et al., 2019), having recruited 51 soccer players. These were split into under-23, under-18 and under-16 players who performed bilateral and UCMJ, 5-, 10-, and 20-meters sprint tests, and a 505 COD speed test. The results were different for each age group, a significant correlation ($p < 0.01$) between the UCMJ inter-limb asymmetries and a decrement in the 10-meter sprints in the under-23 group and with the 5- and 20-meter sprint time in the under-18 group being found. In addition, significant correlations ($p < 0.05$) were observed in the under-23 and under-18 group between the UCMJ inter-limb asymmetries and the decrement in the performance in the other test, except for the 5-meter sprint test in the under-18 group.

According to this, a large diversity of results has been reported for this research topic. So, the aim of this research was to investigate the effects of inter-limb vertical jump asymmetries in physical performance in U-19 elite soccer players. It was hypothesized that larger inter-limb vertical jump asymmetries could be associated with a reduced physical performance in elite young soccer players.

Material & methods

Participants

A convenience sample of 19 U-19 male soccer players was recruited. They had the following characteristics: age (Mean $\pm$ SD, years) = 18.42 ± 0.69 ; body mass (Mean $\pm$ SD, kg) = 71.87 ± 6.30 ; height (Mean $\pm$ SD, cm) = 179.21 ± 0.06 . The players belonged to the first U-19 team of a professional Spanish club. All the players had a license in the Spanish football federation during the 2018/2019 season. Four weekly training sessions were performed during the competitive period. At the time of the study, no injuries were diagnosed and no player was in a recovery process. All the participants and their parents or guardians were informed in advance about the purpose of the study and the type of evidence to be submitted. Each of the players and their parents or guardians gave their signed informed assent following the recommendations of the Declaration of Helsinki. The study was approved by the ethics committee of the Centro de Estudios Universitarios Cardenal Spínola CEU Andalucía.

Procedure

Testing was conducted over five different days on an artificial grass pitch, where the team usually trains and plays league matches, under stable weather conditions. All the participants were equipped with their own soccer boots and their regular training outfit. The research was carried out at the start of the training sessions. The players were evaluated seventy-two hours after their last competition match during five weeks, in the last month of the season. They were encouraged to have their last meal three hours before the training session. Prior to the test, a general and specific warm up was performed, including different attempts of the different tests. All the players were familiarized with the exercises used in the protocol as part of the training used during the season, so additional training was not needed. To obtain measures of the different tests included in the study an iPad 2018 (Apple®, EEUU) device was used, with a 1080 Full HD movie recording and slow motion of 120 frames per second. Two PhDs and one graduate in sport sciences supervised the tests through image selections.

CMJ, DJ and horizontal jumps.

The countermovement jump (CMJ), drop jump (DJ) and horizontal jump tests were measured using My Jump 2 App, previously validated for these jump tests (Balsalobre-Fernandez et al., 2015; Haynes et al., 2019). For the CMJ the players were in a standing position with their hands on their hips. From this position, the participants began a downward movement until they reached a crouching position with a knee angle of about 90°, followed by a jump for maximal height (Jiménez-Reyes et al., 2014). The DJ was started by instructing the participants to stand on a 45 cm bench with both legs stationary. The participant dropped from the platform, landed in front of it, and immediately jumped vertically (Yokoyama et al., 2019). The procedure was similar for the UCMJ and UDJ, but the jump was performed with only one leg. In the horizontal jump, the subjects' trunks were in a position similar to their vertical squat jump position. The subjects were instructed to jump as far as possible and land on 2 feet. The distance measured was from the starting line to the subject's closest heel (Meylan et al., 2009). Each player performed 3 jumps for each test with a recovery time of 2 minutes between jumps to avoid the influence of fatigue (Lockie et al., 2014), alternating between legs in the case of unilateral jumps. The best of the three jumps was selected. If a jump was detected as wrong by the observers, it was rejected and repeated after the rest time.

Sprint test

The sprint test were measured using the My Sprint APP, previously validated (Romero-Franco et al., 2017). The start, finish and the different distance lines were marked with cones. The front foot was placed 0.3 meters before the first timing gate, and the sprint started when the player was ready (Bishop, Brashill, et al., 2019). Each player performed three tries over the 30-meter distance, with a rest time of three minutes between tries. The best time in the 10-, 15-, 20- and 25-meter split distance was selected for study.

Eccentric hamstring strength

The "Nordic hamstring" exercise was used to obtain the measures, recording the data with the "Nordics" APP, similar to the valid and reliable video recording used in other studies (Lee et al., 2017). Following previous research, the "break-point angle" was taken, defined as the angle at which the individual can

no longer resist the increasing gravitational moment and falls to the floor, this being accepted as a measure of eccentric hamstring strength (Lee et al., 2017; Sconce et al., 2015). Each player performed three tries with a recovery time of two minutes, the longest break-point angle being selected.

505 change of direction test

The change of direction (COD) sprint test, including 5-0-5 has been widely used in soccer, showing a high validity and reliability (Altmann et al., 2019). The “COD timer” App was used for data recording, marking the start, 10-m in and 15-m line with cones (Balsalobre-Fernández et al., 2019). The players sprinted 15-m and then performed a 180° turn off coming back to the 10-m line. The time started when the player crossed the 10-m line and after turning 180°, coming back to the 10-m line (Bishop, Brashill, et al., 2019). Three tries were made with the right leg (COD-R) and three with the left (COD-L), establishing two minutes of recovery between each attempt. The fastest time was selected for the study.

Statistical analysis

For the statistical analyses, the software IBM SPSS statistics 22 was used. Data are expressed as means and standard deviations. The confidence level of the measurements was estimated at a 95% confidence interval for the mean. In order to find out the consistency of the measurements, the intraclass correlation coefficient (ICC) and coefficient of variation (CV) were calculated between repeated measurements. The two-way random absolute agreement model was used. (Cormack et al., 2008).

The interpretation of the ICC and the 95% confidence interval were calculated and categorized as excellent (0.90–1.00), good (0.75–0.9), moderate (0.50–0.75), or poor (<0.50) (Koo & Li, 2016). The normal distribution of the data was checked by the Shapiro-Wilk test. The homogeneity of variance was evaluated by Levene’s test. To establish if there were correlations between the inter-limb jump asymmetries and other physical tests, Pearson’s *r* and the coefficient of determination (*r*²) were calculated, setting the statistical significance at *p* < 0.05. The inter-limb jump asymmetries were calculated using a standard percentage equation employed in previous studies (Bishop, Brashill, et al., 2019):

$$100/(\text{maximal value}) \times (\text{minimal value}) \times (-1) + 100.$$

Results

All the data were normally distributed (*p* > 0.05). The ICC shows good to excellent values for all the variables except moderate values for COD-R, COD-L, 10- and 15-meter sprint and poor values for the NBP (Table 1),

Table I. Descriptive analysis of the variables studied.

	Mean ± SD	Range	CI (95%) [‡]	ICC [¥]	CV [§]
COD-R (s)	2.28 ± 0.6	2.39-2.20	2.25–2.30	0.635	2.63
COD-L(s)	2.29±0.6	2.40 -2.12	2.25-2.32	0.704	3.04
CMJ (cm)	44.16±5.16	54.48-37.08	41.67-46.65	0.902	11.69
DJ (cm)	46.34±5.94	57.30-34.86	43.47-49.20	0.906	12.82
HJ (cm)	264.10±16.82	296.95-236.20	21.22-25.04	0.875	6.37
CMJ-R (cm)	23.13±3.95	30.64-17.23	21.83-25.44	0.923	17.11
CMJ-L (cm)	23.64±3.73	29.63-16.48	21.83-25.44	0.915	15.81
DJ-R (cm)	26.11±4.05	32.72-20.48	24.16-28.07	0.937	15.54
DJ-L (cm)	27.37±4.48	37.08-20.48	25.21-29.53	0.898	16.38
NBP (°)	126.11±9.47	149.3-111.4	130.68-121.55	0.418	7.50
% Asymmetry CMJ	8.05±6.77	25.14-0	11.32-4.79	-	-
% Asymmetry DJ	9.70±5.41	19.78-0	12.31-7.09	-	-
V10 (s)	1.90±0.07	2.01-1.78	1.86-1.93	0.601	3.95
V15 (s)	2.56±0.08	2.69-2.37	2.52-2.60	0.695	3.27
V20 (s)	3.16±0.09	3.33-2.92	3.11-3.21	0.827	3.22
V25 (s)	3.72±0.12	3.97-3.34	3.66-3.78	0.904	3.44
V30 (s)	4.22±0.12	4.44-3.91	4.16-4.28	0.913	3.15

* Mean ± Standard deviation; [‡] 95% confidence interval; [¥] Intraclass correlation coefficient; [§] Coefficient of variation.

Abbreviation: CMJ, countermovement jump; DJ, drop jump, HJ, horizontal jump; V10, velocity at 10m; V15, velocity at 15m; V20, velocity at 20m; V30, velocity at 30m; CMJ-R; countermovement jump, right leg; CMJ-L, countermovement jump, left leg; DJ-R; drop jump, right leg; DJ-L, drop jump, left leg; COD-R, change of direction, right leg; COD-L; change of direction, left leg; NBP; Nordic break point; NT, Nordic torque

The individual asymmetry for each player in UDJ a UCMJ ranged from 0 to 25.14% in UCMJ and from 0 to 19.78% in UDJ (Figure 1).

Fig I. Individual jump inter-limb asymmetries.

U-CMJ, unilateral countermovement jump; U-DJ, unilateral drop jump

The correlations observed between the percentage of inter-limb jump asymmetry in UCMJ and the physical test performed only obtained significant values between the inter-limb UCMJ asymmetry and the horizontal jump ($r = -0.489$; $p < 0.05$) (Table 2).

Table II. Pearson r correlation between the % of interlimb asymmetry in CMJ and the different variables measured.

	CMJ	DJ	HJ	V10	V15	V20	V25	V30
% Asymmetry	r	-0.211	-0.078	-0.489*	-0.073	0.077	0.249	0.350
	r^2	0.387	0.751	0.034	0.768	0.754	0.304	0.141
% Asymmetry		CMJ-R	CMJ-L	DJ-R	DJ-L	COD-D	COD-L	NBP
	r	-0.044	-0.043	0.000	0.119	0.401	0.406	-0.160
	r^2	0.858	0.860	0.999	0.626	0.088	0.085	0.514

*Statistical significance at $p < 0.05$

** Statistical significance at $p < 0.01$

Abbreviation: CMJ, countermovement jump; DJ, drop jump, HJ, horizontal jump; V5, velocity at 5m; V10, velocity at 10m; V15, velocity at 15m; V20, velocity at 20m; V30, velocity at 30m; CMJ-R; countermovement jump, right leg; CMJ-L, countermovement jump, left leg; DJ-R; drop jump, right leg; DJ-L, drop jump, left leg; COD-R, change of direction, right leg; COD-L; change of direction, left leg; NBP; Nordic break point.

The correlations observed between the percentage of inter-limb jump asymmetry in UDJ and the physical test performed only obtained significant values between the inter-limb DJ asymmetry and the NBP ($r = -0.579$; $p < 0.01$) (Table 3).

Table III. Pearson r correlation between the % of interlimb asymmetry in DJ and the different variables measured.

	CMJ	DJ	HJ	V10	V15	V20	V25	V30
% Asymmetry DJ	r	-0.211	-0.016	-0.298	-0.045	0.041	0.005	-0.018
	r^2	0.387	0.948	0.215	0.856	0.868	0.984	0.940
% Asymmetry DJ		CMJ-R	CMJ-L	DJ-R	DJ-L	COD-D	COD-L	NBP
	r	0.066	0.129	-0.262	0.048	0.316	0.158	-0.579**
	r^2	0.789	0.599	0.2779	0.846	0.188	0.519	0.009

*Statistical significance at $p < 0.05$

** Statistical significance at $p < 0.01$

Abbreviation: CMJ, countermovement jump; DJ, drop jump, HJ, horizontal jump; V5, velocity at 5m; V10, velocity at 10m; V15, velocity at 15m; V20, velocity at 20m; V30, velocity at 30m; CMJ-R; countermovement jump, right leg; CMJ-L, countermovement jump, left leg; DJ-R; drop jump, right leg; DJ-L, drop jump, left leg; COD-R, change of direction, right leg; COD-L; change of direction, left leg; NBP; Nordic break point.

Discussion

The aim of this research was to investigate the effects of inter-limb vertical jump asymmetries in physical performance in U-19 elite soccer players.

Table I shows in detail the results obtained in the variables studied. The ICC showed a high reliability for the data of the variables studied. However, the NBP showed values less than 0.50. This may be explained by the experience of the effects on the good reliability of the data that the structured and conditioning training performed during the season could have had (Bishop, Berney, et al., 2019).

The data reported in terms of CMJ (Coratella et al., 2018; Rebelo et al., 2013), UCMJ height (Bishop, Brashill, et al., 2019), COD (Bishop, Brashill, et al., 2019), sprints (Coratella et al., 2018; Rebelo et al., 2013; Wdowski& Gittoes, 2019; Wing et al., 2018) and percentage of inter-limb asymmetries in UCMJ (Bishop et al., 2020) are similar to the data reported in other studies for the same group of age and soccer level. The NBP was close to angles obtained in professional players (Lee et al., 2018). However, the horizontal jump test, DJ and UDJ heights are higher than similar samples. This might be interpreted as due to the seasonal plyometric training periodized in the usual training of the team, which has induced an improvement in these variables, as has been shown in previous research (Barbalho et al., 2018). In addition, DJ and UDJ started the movement with a drop height higher than other previous research with similar samples, obtaining larger jump height values.

Significant correlations were only found between the percentages of asymmetries in UCMJ and the horizontal jump ($r = -0.489$; $p < 0.05$) (Table 2). The results were similar to other research with few effects of inter-limb jump asymmetries on physical performance (Bishop, Turner, et al., 2019; Lockie et al., 2014). In addition, despite finding different results than other studies (Bishop, Brashill, et al., 2019; Bishop, Read, et al., 2018), positive correlation values of sprint times and COD are shown (except for the 10-meter sprint) and negative values in the jump test, so there was a performance reduction with a larger asymmetry in UCMJ, but significant “ r ” values were not attained. The main argument for explaining these results is the high level and age of the sample included in this study. A reduction in inter-limb jump asymmetries with training age has been previously found (Fousekis et al., 2010), which could explain the low percentage of inter-limb asymmetries in UCMJ (Table 1). Percentages lower than 10% (Bishop, Brashill, et al., 2019) or 15% (Lockie et al., 2014) have been suggested to not have an influence on physical performance. Figure 1 shows how only three players are above the 15% threshold and four over the 10% threshold.

However, this affirmation cannot be used for the horizontal jump, which obtained significant values, with larger UCMJ asymmetries. None of the previous research has correlated jump percentages of inter-limb UCMJ asymmetries with the bilateral horizontal jump. It may be that the horizontal jump is the least specific test if we compare it with the efforts required in a soccer match, so the soccer players included in the sample do not develop an adaptive response to the test as has been proved that they do in the COD test (Lockie et al., 2014).

Significant correlations were only found between the percentage of asymmetries in UDJ and a shorter NBP angle ($r = -0.588$; $p < 0.01$) (Table 3). Only one study has used UDJ to find out how inter-limb jump asymmetries affect physical performance (Bishop, Turner, et al., 2019), showing different results in sprints (10- and 30-meter-) and the COD performance than our research. The sample was composed of female adult players, which enforced the previous argument about how sample characteristics have an important influence on this kind of studies. According to the results obtained, the higher jump percentage of inter-limb UDJ asymmetries is related to a shorter NBP angle. During DJ, large eccentric forces are developed (Stojanović et al., 2017) which have a relationship with the eccentric hamstring strength expressed by the NBP during the Nordic hamstring exercise (Sconce et al., 2015).

The main limitation of the study is the low ICC achieved in the NBP, despite using a valid and reliable method. Furthermore, the results obtained in this research are only applicable to young U-19 elite soccer players. As practical applications, practitioners should be aware of how the inter-limb jump asymmetries affect the physical performance. Larger inter-limb jump asymmetries could reduce the results obtained in physical capabilities, especially in asymmetries values larger than 10-15%, so a strength training to achieve values under this percentage may be considered. In addition, as all the tests performed in this research were measured with previously validated apps, maximizing the portability of the equipment and enhancing the familiarity and the ecological validity for the athlete (Peart et al., 2019), practitioners might easily replicate this study's results in the field.

Conclusions

The results show a low percentage of inter-limb asymmetries in UCMJ and UDJ, maybe influenced by the sample level and age. In addition, poor correlations between the inter-limb vertical jumps asymmetries and a decrement in the physical performance in the sample studied. Significant correlations were only established between the inter-limb CMJ asymmetries and a decrement in the horizontal jump and between the inter-limb DJ asymmetries and a lesser NBP angle. Thus, asymmetries between legs could not influence the sport performance in soccer players with a high level of expertise in their sport. The methodology used on this research makes an easy reproducibility for researches and coaches possible.

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