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The influence of unilateral jumping asymmetry on acceleration and speed performance, in U10 and U15 groups of youth soccer players

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Abstract

Introduction. **Soccer players perform many actions with one limb, like stop and turn and kicking a ball. A large number of repetitions could create limb asymmetries.** Aim of Study. **The aims of the present study were to quantify limb asymmetries from unilateral three kinds of jumps (single-leg countermovement jump – SLCMJ, single-leg long jump – SLLJ, and single-leg triple jump – SLTJ) and examine their effects on acceleration (10 m sprint test) and on speed (20 m sprint test) in two different age groups.** Material and Methods. **Two groups (U10 (9.9 ± 0.3 yrs) and U15 (14.6 ± 0.8 yrs)) of nineteen youth male soccer players each, performed an SLCMJ, SLLJ, SLTJ, and a 20 m sprint test. A paired samples T-test was used to compare the two limbs. Pearson's correlations were used to investigate the relationships between limb asymmetries and performance on acceleration and speed.** Results. **In U10 group, SLCMJ height asymmetry ($p < 0.05$) showed no association with acceleration and speed. However, SLTJ ($p < 0.05$) asymmetries were associated with slower acceleration times ($p < 0.05$). Also, SLLJ asymmetries correlated with a lower speed at the 20 m sprint test ($p < 0.05$). In U15 group, SLCMJ height asymmetry ($p < 0.05$) showed no association with acceleration and speed.** Conclusions. **The results from this study highlight that the SLTJ and SLCMJ could be used for identifying limb asymmetries in U10 and U15, respectively.**

KEYWORDS: single leg jump, asymmetry, performance, youth soccer.

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Introduction

Soccer is an intermittent-type of sport that incorporates actions with low and high intensity and duration. In elite soccer, players cover distances around 10-13 km during matches and perform a lot more than 1.000 activities in a match; like accelerations, decelerations, jumps, changes of direction and others [21]. Many of these particular abilities are based on strength [29]. The importance of this ability leads the trainers to focus on this issue. They want to know the level of the strength capacity of their players to prepare suitable training programs. Also, with strength tests, they check limb asymmetries because this is a factor of an increased injury risk. Specifically, an athlete who exhibits inter-limb asymmetries > 15% has been associated with increased injury incidence [1]. Furthermore, limb asymmetries may have a negative impact on athletic performance [20].

Between-limb asymmetries are commonly accessed via isokinetic dynamometer [6, 8], back squat [8, 14] unilateral mid-thigh pull and unilateral jump tasks [16, 20]. All of the aforementioned methods have been shown to be sensitive and reliable when identifying differences between limbs. However, some of the mentioned measurements require expensive equipment, specific staff to perform the test, and an extensive period of time to measure many athletes. For these reasons, trainers use single-leg jumps because they are easy, reliable, and fast to perform for a large group of athletes [23]. Jump tests also offer trainers available methods for lower limb power assessment [13]. In literature, we can see that researchers use many kinds of horizontal and vertical jumps to estimate asymmetries. More specifically, some types of jumps that mostly used are the countermovement jump (CMJ) [3,17], the drop jump (DJ) [19], the standing broad jump (SBJ), and the triple broad jump [17].

The effect of inter-limb asymmetries on physical performance is not clear. Some studies indicate the negative effect of inter-limb asymmetries in jump and sprinting performance [3], and on change of direction (COD) performance [4]. However, other researchers mentioned that asymmetry has no effect on speed or COD performance [9, 17]. These conflicting results could be explained by the methodological differences between studies (e.g. subjects that participate, jump tests that were used). The literature on this aspect is not extended and further research will help to show the relationship between jumping asymmetries with acceleration and linear speed performance.

Aim of the Study

The aims of the present study were to 1) compare SLCMJ, SLLJ, and SLTJ between dominant (D) and non-dominant (ND) limbs, 2) to investigate the relationship between inter-limb asymmetry from three unilateral jump tests and acceleration and linear speed performance in two different age groups (U10 and U15) of young soccer players. It was hypothesized that significant differences would be found between comparisons of D and ND limb, and additionally that greater asymmetries in jump performance would result in slower acceleration and speed performance.

Material and Methods

Youth soccer players from two local soccer academies participated in the study. The study was conducted after the in-season period for 3 weeks. The subjects performed only conventional soccer practice. Subjects participated in three training sessions per week. The training session included soccer technical skills, tactics, speed and sprint workload and small-sided games. The total duration of training sessions was 90 minutes. In the first two weeks of the study, the participants were familiarized with the jump tests in order to minimize the learning effect error. During the first visit, after the two weeks of familiarization period, the players' body mass, height and sitting height was measured. During the next 2 visits (2nd and 3rd), the participants performed the fitness tests which were conducted 48 hours after the last training session and with the same sequence. More specifically, in the 2nd visit they participated in jump tests and at the 3rd visit in speed tests. At the beginning of each testing session, soccer players performed a 15-minute warm-up, and at the end a 10-minute cool-down period. The participants consumed water ad libit to ensure proper hydration during testing. All training and testing sessions were performed on synthetic grass of soccer field and executed at maximal intensity.

Subjects

Nineteen U10 (age: 9.9 ± 0.3 yrs; height: 140.6 ± 5.3 cm; body mass: 35.9 ± 6.4 kg; training experience: 3 ± 0.3 yrs) and nineteen U15 young soccer players (age: 14.6 ± 0.8 yrs; height: 173.2 ± 10.6 cm; body mass: 61.3 ± 12.8 kg; training experience: 8.2 ± 0.2 yrs) participated in this study. All participants were free from musculoskeletal injuries, participated in ≥ 95% of training sessions of the year, and were not early or late matures. Experimental procedures and potential risks, discomforts, and benefits were fully explained to all boys and parents/guardians prior to participation. Signed informative consent forms were provided by subjects' parents and/or legal guardians. The local Institutional Review Board approved the study, in the spirit of the Helsinki Declaration.

Anthropometric measurements

The body mass was measured to the nearest 0.1 kg using an electronic digital scale with the participants in their underclothes and barefoot. Their standing height was measured to the nearest 0.1 cm (Seca 220e, Hamburg, Germany). In addition, the body fat percentage was estimated based on the sum of four (biceps, triceps, suprailiac, subscapular) skinfold thicknesses measured with a specific caliper (Lafayette, Ins. Co., Indiana) on the right side of the body as described in a previous study [27]. Estimation of body density was calculated according to the Durnin and Rahaman (1967) [10] equation for males under the age of 16 (Equation 1) and their body fat was estimated by the equation of Siri (Equation 2) [26].

$$\text{Body density (g/cc)} = 1.1533 - 0.0643 \times \\ \times [\log (\text{sum of four skinfolds})]$$

Equation 1

$$\%BF = [(4.95/\text{body density}) - 4.5] \times 100$$
Equation 2

Assessment of maturity status

The chronological age at peak height velocity (PHV) of the players was estimated using the equation proposed in 2015 by Moore et al. [22]. Early matures were defined as players with an estimated chronological age at PHV of less than 13 years of age. Average matures were defined as players with an estimated chronological age at PHV between 13 and 15 years of age. Late matures were defined as players with an estimated chronological age at PHV more than 15 years of age [25].

Speed testing (ST)

A 20 m sprint test with 10 m splits (0-10 m was measured as well) was used to measure speed performance. Sprint testing was performed with the participants wearing soccer shoes on the synthetic grass of a soccer field. After a 5-second countdown, the participants ran through 3 infrared photoelectric gates (Microgate, Bolzano, Italy) that recorded times at each gate. The participants sprinted from a standing starting position with the toe of the front foot approximately 0.3 m behind the first gate. Photocells were placed 0.6 m above the ground (approximately at the hip level) to capture the movement of the trunk rather than a false signal because of limb motion.

Single-leg standing long jump (SLSLJ)

The participants began by standing on the designated testing leg and their hands on the hips. The participants were then instructed to jump as far forward as possible and land on the same leg. The horizontal distance between the starting line and the heel of the rear foot was recorded with a tape measure to the nearest centimeter.

Single-leg triple jump (SLTJ)

The participants began by standing on the designated testing leg and their hands on hips. Subjects were instructed to take three maximal jumps forward (landing on the same leg throughout) with the intention of minimizing ground contact times after the first and second jumps. The horizontal distance between the starting line and the heel of the rear foot was recorded with a tape measure to the nearest centimeter.

Single-leg countermovement jump (SLCMJ)

The participants stood in an upright position, with feet positioned hip-width. To begin the test one leg was lifted off the floor. Subjects then performed a countermovement to a self-selected depth followed by a quick upward vertical jumping as high as possible. All jumps were performed with the arms on the body. The height was measured with Myotest equipment (Myotest, Switzerland).

Asymmetry index

We used the asymmetry angles to calculate the asymmetries. A previous study [2] proposed this method as the most appropriate for calculating asymmetries. The asymmetry index was calculated by the formula proposed by Zifchock et al. (2008) [30] ($45° - \arctan[ND/D])/90° \times 100$). In accordance with Dos'Santos et al. (2017) [9] dominant leg was the leg that produced the furthest jump.

Statistical analysis

Data are presented as means ± SD. Data normality was verified with the 1-sample Kolmogorov-Smirnov test; therefore, a nonparametric test was not necessary. Confidence intervals (CI) (95%) and coefficient of variation (CV) were assessed. Differences between D and ND legs were assessed with paired samples t-tests. The relationships between D–ND asymmetries with acceleration and speed performance were analyzed using Pearson's correlation and were Bonferroni corrected to reduce the likelihood of type 1 error. The level of significance was set at $p < 0.05$. The SPSS version 18.0 was used for all analyses (SPSS Inc., Chicago, IL, USA).

Results

All the tests had acceptable between-trial consistency (all CV values < 10%). Table 1 presents the mean values of D and ND limb and the differences between limbs. Correlations between jump test asymmetries and sprint tests are presented in Table 2. In U10 and U15, results indicated that significant differences were demonstrated between D and ND performance in SLCMJ ($p < 0.05$), in SLTJ ($p < 0.05$), and in SLCMJ ($p < 0.05$), respectively. In U10 asymmetries during the triple test were associated ($p < 0.05$) with slower acceleration times in 10 m test, and the asymmetries during SLLJ were associated with slower sprint times in 20 m test ($p < 0.05$). In U15 no correlations were observed. The correlations between jump asymmetries are presented in Table 3.

Table 1. Dominant vs non-dominant limb comparisons for jump performance

Variable	Dominant		Non-Dominant		Asymmetry	t	P
	Mean	SD	Mean	SD	Index (%)		
			U10				
SLCMJ (cm)	10.82	2.80	9.59*	2.42	3.69	2.491	0.037*
SLLJ (cm)	113	14	107	16	2.00	0.998	0.348
SLTJ (cm)	336	42	314	30	2.33	3.523	0.008*
			U15				
SLCMJ (cm)	16.22	3.15	15.40	3.24	1.73	2.347	0.031*
SLLJ (cm)	188	33	184	31	0.71	1.704	0.107
SLTJ (cm)	565	75	567	70	0.17	0.171	0.928

Note: SLCMJ – single leg countermovement jump; SLLJ – single leg long jump; SLTJ – single leg triple jump
* denotes significant difference with dominant limb at $p < 0.05$

Table 2. Pearson's correlations between jump asymmetries and sprint performance

Variable	SLCMJ		SLLJ		SLTJ	
	r value	P value	r value	P value	r value	P value
			U10			
0-10 m	0.229	0.524	0.585	0.075	0.666	0.0364*
0-20 m	0.226	0.531	0.683	0.030*	0.514	0.129
			U15			
0-10 m	0.210	0.388	0.292	0.225	0.183	0.453
0-20 m	0.314	0.191	0.271	0.261	0.242	0.319

Note: SLCMJ – single leg countermovement jump; SLLJ – single leg long jump; SLTJ – single leg triple jump
* denotes significant correlation at $p < 0.05$

Table 3. Pearson's r correlations between asymmetry scores across jump tests

	U10			U15		
Variable	SLCMJ	SLLJ	SLTJ	SLCMJ	SLLJ	SLTJ
SLCMJ	1	0.415	0.049	1	0.476*	0.638*
SLLJ	–	1	0.203	–	1	0.395
SLTJ	–	–	1	–	–	1

Note: SLCMJ – single leg countermovement jump; SLLJ – single leg long jump; SLTJ – single leg triple jump
* denotes significant correlation at $p < 0.05$

Discussion

The aims of this study were to determine the presence of asymmetries during vertical and horizontal jump tests in two different age groups of young soccer players and to examine relationships between asymmetries measured in these different tasks and sprint performance. In agreement with our hypotheses, significant differences were found between D and ND limb in jumps (SLCMJ, SLTJ in U10 and SLCMJ in U15). Additionally, for U10 correlations were observed between SLTJ and acceleration, and between SLLJ and linear speed. In U15, in contrast with our hypothesis, we did not observe any correlations between jump asymmetries and acceleration or linear speed.

Many kinds of sports have actions that occur unilaterally. This can develop an asymmetry between limbs [15]. Soccer is a sport where players perform many actions with one limb (e.g. stop and turn, kicking a ball) [28] and these, after years, could lead to asymmetry. Soccer players usually have a dominant leg for the execution of technical actions. This one-sided use of the legs in the technical actions is another factor that can lead to an asymmetry between limbs. Previous studies mentioned similar results about the differences between limbs [9, 16].

In the present study, in both groups, SLCMJ asymmetry was greater than the asymmetry observed in the other two kinds of jumps (SLTJ and SLLJ). This is in agreement with the results of previous studies [3, 17]. However, this is difficult to fully explain. One possible explanation proposed by previous researchers could be the familiarization with horizontal jumps from an early age, more than with unilateral vertical jumps [3, 24]. This may explain why inter-limb differences are less pronounced in horizontal jumping tasks.

Another observation is that U10 soccer players showed asymmetries in two jump tests (SLCMJ and SLTJ), whereas in U15 the players present differences only in SLCMJ. As mentioned by a previous study, any strength or power imbalances between the limbs will tend to reduce as athletes' training experience increases [12].

As mentioned above in U10 inter-limb differences from the SLTJ and from SLLJ correlated significantly with acceleration (10 m) and linear speed (20 m), respectively. Additionally, all r values from the correlations were positive, indicating that larger asymmetries may be indicative of smaller performance. In his previous study Bishop et al., [3] presented that the differences in SLCMJ correlated with sprinting times in elite youth female soccer players. In a more recent study [4] the researchers mentioned that SLCMJ asymmetry showed no association with speed, but the single-leg drop jump asymmetries were significantly correlated with slower acceleration (10 m) and linear speed (30 m).

In U10 no significant relationships were present between asymmetry score, highlighting the independent nature of jumping in this age. However, in U15 positive significant relationship was presented between asymmetry scores (Table 3). From this, we can conclude that in U10 trainers have to know that conducting a single test alone will not provide a complete picture of muscular imbalances. In U15 the asymmetries in SLCMJ correlated with the asymmetries in other jumps (SLLJ and SLTJ) and this means that trainers could use the SLCMJ to estimate lower limb asymmetries in this age group of soccer players. In literature the relations between asymmetries of different jump tests are inconclusive. Some studies indicated no significant relationships [18], and others mentioned that the levels of agreement are typically poor [4].

The limb asymmetries could influence the performance of the players or increase the risk of injury. In most cases, asymmetries > 10% have been sighted carefully because it could have an impact on sports performance [5].

Exell et al. [11] mentioned that the variability during test protocols has to be smaller than limb differences because in other cases the conclusions for asymmetries are not clear. In this study limb asymmetries in jump tests were greater than CV values. Additionally, all CV values were < 10% which is considered acceptable [7].

In this study, we used three jump tests to identify limb asymmetries. These kinds of tests are also used to measure power in athletes. However, another physiological factor that can affect jumping and sprinting performance is strength. Additionally, the technique could affect performance in the above tests. The familiarization could help to decrease this effect but only with the biomechanical analysis we can understand the merge of technique effect.

One of the limitations of this study is that we didn't measure the strength of the limbs. As mentioned above strength could play a significant role in sprinting and jumping performance. Another limitation is that the results are only applicable to youth U10 and U15 male soccer players. Future research should aim to provide comparisons across different youth ages and gender and use more specific equipment to measure strength.

Unilateral jump tests can be used to estimate limb asymmetries in an easy and fast way, especially in team sports. The lack of relationships between jump asymmetries in U10 indicates the individual characteristics of asymmetry. Also, the need for the use of more than one test in order to estimate lower inter-limb asymmetries is present. In U15 the relationship between asymmetry scores in the three jump tests indicates that one test could be used for the assessment of asymmetry, and the SLCMJ seems to be the most specific. Soccer is a sport that can lead to limb asymmetries, therefore trainers have to pay attention to limb asymmetries and they have to minimize them under 10% with specific training programs.

Conclusions

The results from this study highlight that in U10 the use of SLCMJ and SLTJ appears to be the most appropriate jump tests for identifying limb asymmetries. In U15 the most appropriate seems to be the SLCMJ test. These are simple tests that are easy to perform on a soccer team in accordance to identify limb asymmetries in these age groups. If the difference (asymmetry) is greater than 10%, trainers have to eliminate that with specific and individualized strength and power programs.

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