LATERALITY OF THE LEGS IN YOUNG FEMALE SOCCER PLAYERS

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ABSTRACT

Purpose. The aim of the present study was assessment of laterality of the legs of young female soccer players and their non-training counterparts. **Methods.** The study sample comprised 9 female soccer players and 19 non-training girls. They underwent three measurement sessions, one every six months. The applied tests included kinesthetic differentiation, rate of local movements, static balance, single-leg hop, rate of global movements, strength and speed, and functional asymmetry of the legs tests. **Results.** The soccer players were better than the controls in their performance of the rate of local movements, rate of global movements, kinesthetic differentiation, single-leg 15m timed hop and static balance tests. Smaller differences between the results of the left and the right legs in soccer players, than in non-training girls, were noted in the rate of local movements, rate of global movements and kinesthetic differentiation tests. In the static balance test, the differences were greater in the group of soccer players. **Conclusions.** Lateralization of the lower limbs is a highly complex characteristic with a different variability in athletes than in non-training individuals. The results of the present study also point to the specialization of soccer players' left legs in body balance and single-leg hop tests.

Key words: laterality, female soccer, coordination, asymmetry

Introduction

Functional asymmetry of the legs is a natural phenomenon in human development. About the age of 12, the asymmetry becomes stabilized and the lateralization profile becomes well-established [1–3]. Ambidexterity is the lack of dominance of any extremity. It can cause coordination disorders and problems with learning new motor skills necessary in sport practice and activities of daily living. According to Atkins et al. [4], the functional asymmetry of the legs becomes more visible in puberty. Before and after puberty, the function of the left and right lower extremities may not reveal statistically significant differences.

In sport, the direction of functional asymmetry is crucial. On the one hand, stimulation of lateralization in sport training may significantly improve children's psychomotor abilities [5–8]. However, the confinement of sport training to one side of the body can also decrease these capabilities [9, 10]. On the other hand, a specific direction of lateralization (left-footedness or left-handedness) can be an important element of surprise to the opponent in sport competition. Soccer players, who can kick with either foot, can effectively implement all tactical assumptions.

A training load that is too heavy can, not only contribute to the risk of injury, but delay meniscus, tendon and joint recovery, which, as a consequence, could lead to premature osteoarthritis [11]. The assessment of dynamic asymmetry of the lower limbs, while performing strength, speed, or coordination exercises as well as technical elements, e.g. slalom run with a ball or the repeatability of forces generated during the movement rhythm present in step aerobics, can be used as injury prevention measures [12–15]. Sannicandro with co-authors [16–18] points to excessive differences in dynamic asymmetry of the legs as the cause of frequent injuries of the ankle and knee joints.

The aim of the present study was an evaluation of lateralization of the legs in young female soccer players and in their non-training controls. It is also a usability study of a number of tests comparing the movements of the right and the left legs.

Material and methods

Participants

The study was approved by a Bioethical Commission and by parents of the participating girls. The participants were 9 female soccer players and 19 non-training girls. The players (S) had begun soccer training at the age of 7. They undertook three testing sessions every six months, consisting of general training loads, from 495 to 540 minutes every day in school. The control group (N) only took part in regular PE classes, three times a week, 135 minutes per week.

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Data collection instruments

The participants performed motor coordination tests of the right and the left legs. Six simple and commonly used tests assessing motor coordination components were selected for the study. The tests can be applied in all conditions during PE classes or training sessions. A comparison between the test results of the left legs and the right legs allows for the assessment of the lateralization degree of the legs. The present study also made use of the authors' own optoelectronic measuring apparatus for the administration and control of the tests, registration of movements and precise recording of test results displayed simultaneously on the computer screen [19, 20].

Procedures

The following tests were carried out three times every six months:

Kinesthetic differentiation (KD) – the participant was sitting on a chair, held a light carbon fiber tube (10 mm in outside diameter) between the big toe and the second toe, and then tried to insert the tube into 8 holes (11 mm in inside diameter) on the apparatus, in sequence. The test result is the time in seconds measured from the moment of insertion of the tube into the first hole to the moment of insertion of the tube into the last hole.

Rate of local movements (RLM) – the participant was sitting on a chair and was moving one foot over a 15-cm-long bar placed along the sagittal axis of the body. A single cycle consisted of moving the foot over the bar, touching the ground and returning the foot to its original position. The result was the number of completed cycles.

Static balance (SB) – the static balance test consisted of maintaining body balance while standing on one foot for the longest time possible.

Single-leg hop (SLH) – a one-leg long standing jump test measuring the explosive force of leg muscles (in cm).

Rate of global movements (RGM) – consisted of performing the maximal number of one-foot leaps sideways over a line within 20 s. One complete cycle was a leap over the line on one foot and a return to the original position. The test results were given in completed cycles.

Strength and speed test (SSS) – a single-leg 15m timed hop test – the participant was supposed to cover a distance of 15 m by hopping on one foot as quickly as possible. The test results were given in seconds (SSS) and the number of hops (cycles) (SSN).

The participants performed all the tests using the right leg and then the left leg. Also, the following variables were measured:

Functional asymmetry of the legs (FAL) – footedness: putting out "fire"; kicking the ball; crossing one's legs; long stride over an obstacle. The results of these measurements allowed us to classify the participants as right-footed, left-footed, or with no specific laterality – according to Gabbard [21].

Body build characteristics – the anthropometric measurements included participants' body mass, body height, length and width of the legs, thigh and lower leg length, and thigh and lower leg girth.

Data analysis

The following tests were used in statistical analysis: descriptive statistics, and normal distribution test (Shapiro–Wilk test), Mann–Whitney U test, and Spearman's rank correlation coefficient.

Results

The tests revealed that female soccer players were better than the controls in the KD, RLM, RGM, SSS tests – in majority of three testing sessions. In all other variables, the superiority of one group over the other changed depending on the date of the measurement. However, statistically significant differences were found only when the soccer players' results were better than those of the controls' (Table 1 and 2). The objective of the study was the assessment of lateralization, i.e. the differences between the results of the right and the left legs in participants (R/L). Lower R/L differences in soccer players than in the controls were found in the results of the RLM, RGM and KD tests. In the SB test, the differences were greater in soccer players, and small differences were observed in SSN and SLH (Table 3).

The smallest differences between the right and the left legs were in the SSS test results, which meant that the time of covering the distance of 15 m in single leg hops was almost the same for both legs. However, the left legs required more movement cycles (SSN) to perform this task, i.e. the hops were shorter and more frequent. The numerical values between the right leg and the left leg were different, depending on the examined variable.

The R/L differences also changed in subsequent measurements, in particular, in the KD test results, where the R/L difference was the lowest in the third measurement. In the case of SB, the R/L difference was actually the highest in the second and third measurement.

The statistically significant difference between measurements mostly was between the KD results in both groups between the first, second and the third measurements. More statistically significant differences between testing sessions were found in the N group. In SLH, SSS and SSN were more statistically significant differences (Table 2).

In terms of the whole group, arithmetic mean results for the right legs were better in the RLM, RGM, SSN, KD and SLH tests. In the SB test, the better performance of one leg over the other depended on the date of the measurement. However, in terms of results of individual players, some interesting conclusions can be drawn.

Table 1. Results of motor coordination tests ($M \pm SD$)

Motor coordination tests			1st measurement	2nd measurement	3rd measurement
KD (s)	R	S	25.78 ± 10.42	21.48 ± 10.62	19.12 ± 7.52
		N	27.11 ± 9.79	23.53 ± 7.53	18.51 ± 4.60
	L	S	27.33 ± 12.75	23.92 ± 8.13	18.79 ± 4.99
		N	33.14 ± 17.93	27.65 ± 10.77	19.50 ± 5.44
SB (s)	R	S	**17.20** ** ± 13.36	**15.87** * ± 17.21	19.99 ± 25.2
		N	**5.65 ± 4.17**	**20.21 ± 16.21**	17.11 ± 20.12
	L	S	**15.37** ** ± 15.00	7.77 ± 4.25	24.96 ± 22.07
		N	**6.04 ± 5.57**	7.91 ± 7.12	14.32 ± 17.39
RLM (cycles)	R	S	**24.45** **± 2.23	**25.00** * ±1.91	**25.95** ** ± 1.36
		N	**22.29 ± 2.24**	**23.00 ± 2.42**	**23.55 ± 1.91**
	L	S	**23.70** ** ± 2.35	**24.60** * ± 1.97	**25.20** ** ± 2.10
		N	**21.50 ± 2.51**	**21.43 ± 2.81**	**22.11 ± 2.25**
RGM (cycles)	R	S	**25.25** *± 3.80	**25.30** ** ± 2.77	**25.35** * ± 3.44
		N	**21.55 ± 4.26**	**21.67 ± 3.03**	**22.63 ± 3.52**
	L	S	**24.70** * ± 3.14	**24.10** ** ± 2.49	**24.25** * ± 3.80
		N	**19.51 ± 4.65**	**20.34 ± 3.77**	**21.18 ± 3.16**
SLH (cm)	R	S	**111.80** ** ± 16.25	110.20 ± 14.29	108.30 ± 18.68
		N	**85.84 ± 23.15**	100.50 ± 15.53	110.84 ± 19.37
	L	S	**104.90** ** ± 13.74	106.30 ± 16.38	105.50 ± 17.86
		N	**82.20 ± 17.69**	96.48 ± 15.21	107.20 ± 19.21
SSS (s)	R	S	6.14 ± 0.98	5.58 ± 0.54	6.01 ± 0.74
		N	7.11 ± 2.03	6.54 ± 1.03	5.99 ± 0.97
	L	S	6.38 ± 1.13	**5.53** * ± 0.87	6.10 ± 0.81
		N	7.30 ± 1.68	**6.57 ± 0.99**	6.30 ± 0.87
SSN (cycles)	R	S	14.05 ± 2.21	12.95 ± 1.52	12.80 ± 1.72
		N	15.48 ± 2.64	14.01 ± 2.01	13.86 ± 2.60
	L	S	14.90 ± 3.10	13.05 ± 2.45	13.50 ± 2.10
		N	15.88 ± 3.60	14.46 ± 2.38	14.48 ± 2.50

* $p < 0.05$, ** $p < 0.01$; statistically significant differences between mean tests results of groups S and N, bold means
that between these averages statistically significant difference revealed, asterisks placed by the better average test result
R – right leg, L – left leg, S – training group, N – non-training group, KD – kinesthetic differentiation (s),
SB – static balance (s), RLM – rate of local movements (cycles), RGM – rate of global movements (cycles),
SLH – single-leg hop (cm), SSS – strength and speed test (s), SSN – strength and speed test (cycles)

The variables with a visible superiority of the right legs included the RGM and SLH in female soccer players, and RLM, RGM and SLH in the controls. The left legs performed the SSN test better, i.e. it was easier to perform longer hops rather than more frequent hops on the left leg. The SSN test also revealed the highest number of equal results for both legs. SB turned out to be a variable displaying the superiority of the left legs in soccer players in time, and of the right legs in the control group.

In our results, right-footedness appears to be generally more frequent than left-footedness. In the present study, there were three female soccer players with better left leg results in at least 4 tests (out of 6), during a particular measurement. In the control group, there was one such participant during two measurements and three participants during one measurement.

The differences in test results between the right legs and the left legs have been regarded as negative or positive values, depending on whether the right leg or the left leg scored better on a given test. However, the absolute value of the difference (without a plus or a minus sign) can also provide some interesting conclusions. The scattering of data around the mean is illustrated by the variability coefficient. Table 3 shows the means of these differences and variability coefficients.

The absolute values of arithmetic means show that the differences in KD and SLH in both groups decreased and in SB and RGM decreased in consecutive measurements. The scattering of results around the mean was wider in SB, RLM and SSN, among the controls, than it

Table 2. Statistically significant difference between measurements (*p* values)

Measurements		KD	SB	RLM	RGM	SLH	SSS	SSN
S								
I–II	R							
	L						0.013	0.004
I–III	R	0.013		0.018				< 0.001
	L	0.028						
II–III	R							
	L	0.047					0.001	
N								
I–II	R							0.016
	L					0.003		
I–III	R	0.002	0.040	0.006		0.003	0.047	< 0.001
	L	0.004			0.035	0.001	0.010	
II–III	R					0.002		
	L	0.002				0.014		

S – training group, N – non-training group, R – right leg, L – left leg, KD – kinesthetic differentiation (s),
SB – static balance (s), RLM – rate of local movements (cycles), RGM – rate of global movements (cycles),
SLH – single-leg hop (cm), SSS – strength and speed test (s), SSN – strength and speed test (cycles)

Table 3. Arithmetic means (*M*) variability coefficients (*v*) of absolute values (no plus/minus sign) of differences between the results of the right legs and the left legs

Group measurement		KD	SB	RLM	RGM	SLH	SSS	SSN
S1	*M*	9.2	6.7	1.3	1.5	12.0	0.3	1.4
	v	123	85	69	68	56	141	84
S2	*M*	5.8	12.3	1.7	1.8	7.2	0.7	1.6
	v	113	79	58	86	89	63	43
S3	*M*	3.0	21.9	1.4	2.4	3.9	0.4	0.9
	v	79	88	76	69	107	65	78
N1	*M*	11.6	4.3	1.2	2.3	15.9	0.9	1.7
	v	71	92	101	80	100	85	106
N2	*M*	8.0	3.6	2.1	2.4	8.5	0.5	0.9
	v	104	92	89	77	83	93	115
N3	*M*	4.3	9.2	1.6	2.5	8.5	0.5	1.0
	v	99	107	76	75	98	77	76

S – training group, N – non-training group, KD – kinesthetic differentiation (s), SB – static balance (s),
RLM – rate of local movements (cycles), RGM – rate of global movements (cycles), SLH – single-leg hop (cm),
SSS – strength and speed test (s), SSN – strength and speed test (cycles)

was in female soccer players. The KD results, however, proved otherwise. There was a characteristic closer clustering of KD results in female soccer players, and of RLM and RGM results in non-training controls with each measurement. A greater scattering of SLH results was noted in soccer players with each measurement (Table 3).

The FAL tests revealed left-footedness in four soccer players and two non-training participants, and ambidexterity in one player and two non-training controls, in all three measurements. The absolute numerical values of R/L differences (with no plus or minus sign) did not display correlations with the FAL results. However, the test results of the left leg and the right leg separately were correlated with FAL, although very rarely. In terms of the groups of participants taken collectively, these correlations were only found in the RGM tests results of both legs during the 1st measurement ($r = 0.50$, $p = 0.0072$ for the left legs; $r = 0.45$, $p = 0.0170$ for the right legs).

Another possible relationship was examined between the laterality of the lower legs and body build characteristics. A small absolute numerical value of the R/L difference was strongly correlated in KD, SB and SSN of the players with longer legs, thighs or calves ($r = 0.83$, $p = 0.0053$). In both groups, it was also correlated in the RLM results with short calves ($r = 0.47$, $p = 0.0393$; $r = 0.47$, $p = 0.0403$). In the players' group, the R/L difference in SSS was strongly correlated with wide feet ($r = 0.71$, $p = 0.0007$). There were no correlations between the R/L differences and body build characteristics in SLH and RGM.

In terms of better results of one leg over the other in relation to body build, it was noted that better results of the left legs in players were correlated in KD and RLM with short legs, calves, feet and longer thigh girth (from $r = 0.48$, $p = 0.0395$; to $r = 0.79$, $p = 0.0108$), and in SLH with short calves and wider feet (from $r = 0.70$, $p = 0.0368$ to $r = 0.74$, $p = 0.0235$). In soccer players also better results of the left legs in players were correlated in RGM with long calves and narrower knees (from $r = 0.79$, $p = 0.0108$ to $r = 0.83$, $p = 0.0061$). Better results of the left legs were not correlated in the SS tests, and FAL test results were not correlated with differences or better results of one leg over the other.

Discussion

Olex-Zarychta and Raczek assume that, contrary to earlier reports, the quality of limb movement, including lower limbs, is the effect of not only brain hemispheres. This effect is also from peripheral sensors as visual receptors, vestibular receptors, proprioceptors and biomechanical factors [1]. Therefore, they also linked with some body build characteristics.

Among our results, the two traits, which did not show decidedly better results in female soccer players, were SLH and SSN, i.e. variables related to a jumping length. The players' SLH results deteriorate in time, and improve in the non-training group. Observations of body build changes indicate that, during the first measurement, non-training participants had smaller body build dimensions; however, in the third measurement, they had greater body height, body mass and leg length parameters than the players. On the other hand, coordination-orientated tests were performed better by lighter soccer players, especially in the third measurement, and by better trained ones. The smallest R/L differences were noted in the 15m single-leg hop test. The performance of this test requires strength and high frequency of movement. A good test result can be attained by taking both long and frequent hops. The complexity of this motor task might have leveled the R/L differences. The left legs required more movement cycles to complete this test, i.e. hops on the left foot were shorter, but more frequent.

As for more typical coordination skills, which require particular movement precision (KD, RLM and RGM), the R/L differences were smaller in the group of soccer players than in the non-training group. It was reversed in the SB test results. It can be assumed that the players' coordination training makes the capabilities of both legs similar.

Observed right-footedness was more frequent in test results, but it did not occur in all tests in each participant. In the SB test, the support function was often taken over by the left leg. Also, a tendency towards left-footedness was noted in the SLH test in female soccer players, in particular, in the third measurement, and in SSN in non-training controls. Both types of sidedness associated with the length of single-leg hops and point to the variability of R/L differences in the single-leg hop test.

SLH involved the greatest differences in test results between the measurements. It also features a greater scattering of absolute R/L difference values from the arithmetic mean. Absolute values (with no plus or minus sign) of arithmetic means indicate that R/L differences in SLH in both groups decrease in consecutive measurements. In SLH, the size of the R/L differences is not correlated with body build (like RGM). However, R/L differences show that better results of the left legs than the right legs are associated with wider feet.

A comparison of the test results with body build prove that better test results, attained by the left legs, are more often associated with shorter and wider lower limbs.

Footedness, as identified by the FAL tests, turned out to be the same during all three measurements. The better performance of the right or the left leg was changing in time, i.e. from one measurement to another. The lack of correlations between FAL test results and R/L differences indicate a high complexity of coordination skills of the lower limbs. A correlation like this can only be found in RGM during the first measurement. Since it does not occur in the subsequent measurements, nor among non-training controls, it can be assumed that soccer training does affect coordination tests whose results begin to move further away from the FAL results.

Lateralization of the lower limbs is a highly complex characteristic [22], with a different variability in athletes than in non-training individuals. The results of the present study also point to the specialization of soccer players' left legs in body balance and single-leg hop tests.

Conclusions

Lateralization of the lower limbs is a highly complex characteristic with a different variability in athletes than in non-training individuals. The results of the present study also point to the specialization of soccer players' left legs in body balance and single-leg hop tests.

As for the usability of the applied tests, in terms of attained results, the Test Functional Asymmetry of the Legs did not reflect the legs asymmetry. Thus, it appears necessary to use more accurate tests in sport to examine movement differences between the right and the left legs. The strength and speed test (SS) yielded stable, reliable

and repeatable results revealing small R/L differences. The advantage of the results of this test is their relative independence of body build characteristics. This test is recommendable as it provides reliable data on motor coordination in the form of two results: performance time and number of completed movement cycles. The static balance (SB), single-leg hop (SLH) and strength and speed (SSN) tests bring out the capabilities of the left legs. The application of these tests in the present study, e.g. SB in female soccer players, shows that they can reveal the specialization of the lower limbs due to training of non-symmetric movements. The kinesthetic differentiation (KD) test is particularly usable for indicating changes of R/L differences in time. The rate of local movements (RLM) and rate of global movements (RGM) tests most often indicated right-footedness. Their usability is rather limited for examining the abilities of the left legs.

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