Original article

Forward and multiple directions single leg hop results in soccer players: evaluation of pre-season

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Abstract. *Study Objectives:* This study aimed to determine the Single Leg Hop Tests (SLHT) and Limb Symmetry Index (LSI) and to examine possible injury risks in football players with lower extremity strength differences. *Methods:* The study group of the research consisted of 21 male football players between the ages of 18-35 who had at least 10 years of active football training and were regularly trained. Participants had 3 different SLHT on dominant (DS) and non-dominant (NDS) sides; Single Leg Hop for Distance (SL), Crossover Hop for Distance (CHD), and Medial Side Triple Hop for Distance (MSTH) tests were applied. Paired sample t, One Way ANOVA, Tukey, and Pearson tests were used in the statistical analysis of the research. *Results:* In the SL test, it was determined that the left side had a higher jump distance than the right side ($p<0.05$), but the CHD and MSTH tests did not reveal any significant differences ($p>0.05$). In different SLHT, LSI was detected at the rates of 97.22% in the SL test, 99.71% in the CHD test, and 99.19% in the MSTH test. *Conclusion:* When the results of our research were evaluated, it was determined that the detected LSI ratios reflected very low levels of asymmetries and that the football players forming the subject group had balanced strength developments between the DS and NDS limbs. In this context, it was evaluated that the risk of injury in the pre-season measurements of the football players was low.

Key words: Single Leg Hop Test, Knee Strength, Football, Limb symmetry index

Introduction

Football is one of the most popular sports worldwide, both at the professional and amateur levels (1). Football is considered as a sport in which asymmetries between the limbs and strength differences between agonist-antagonist muscle groups are possible, especially in terms of the continuous realization of higher-level force production of the dominant limb frequently used kicks (2-7). Lower extremity injuries, which are common in football, are associated with asymmetries between the limbs and imbalances between muscle strength (8). Lower extremity functional performance tests are frequently preferred for returning to sports, especially after anterior cruciate ligament and Achilles tendon injuries applied to groups such as healthy, obese, and athletes (9,10). Limb asymmetry index (LSI) is determined as a result of evaluations between the extremities in athletes and sedentary people, and it is stated that the risk of injury increases during sportive performances if this index differs more than 10-15% (11,12).

Lower extremity strength measurement methods, which are frequently used in the detection of LSI, are very important in terms of accurately evaluating basic functional characteristics such as strength, flexibility, power, balance, and displacement in athletes and sedentary people (13). Although many different methods are used in lower extremity strength measurements today, functional performance tests (SLHT) and isokinetic tests are frequently preferred as they provide valid and reliable measurements (14-21).

Sports scientists and physiotherapists work for various purposes such as evaluating athletic performance, monitoring functional status, monitoring post-injury rehabilitation activity, and determining the time to return to sports and following these purposes they benefit from SLHTs such as Single Leg Hop for Distance (SL), Crossover Hop for Distance (CHD) and Medial Side Triple Hop for Distance (MSTH) (13, 22, 23). SLHTs, which are one of the most preferred measurement methods in terms of their ease of application as well as requiring minimum equipment and expertise, are of great importance in the analysis of the functional status and disability risks, especially as a result of the detection of asymmetries between the extremities, with the tests performed following the movement forms for daily life and sports activities (13, 15, 22, 16, 17, 24, 25). It is considered that detecting LSIs with lower extremity strength measurement methods, especially in sports branches such as football where strength differences between dominant and non-dominant limbs are possible, may contribute to the planning of strength exercises to eliminate asymmetries and to reduce the risk of lower extremity injuries, which are commonly observed in football players (26).

This study aimed to determine the Single Leg Hop Tests (SLHT) and Limb Symmetry Index (LSI) and to examine possible injury risks in football players with lower extremity strength differences.

Material and Methods

Participants and Experimental Design

The study was designed according to a randomized repeated measures experiment design. Twenty-one male football players between the ages of 18-35, who had at least 10 years of active football training and regularly trained, voluntarily participated in the study. The minimum number of subjects to participate in the study was determined through GPower 3.1.3. program (Effect size: 0.93, Actual power:0.93). The subjects visited the laboratory twice at 24-hour intervals. At the first visit, the participants were informed about the application protocols and their height, weight, and body mass index (BMI) measurements were taken. At the second visit, the subjects were randomized with practice cards and applied three different lower extremity SLHTs.

The tests applied to the lower extremity were as follows.

1. Single Leg Hop for Distance (SL)
2. Crossover Hop for Distance (CHD)
3. Medial Side Triple Hop for Distance (MSTH)

Procedures

Single Leg Hop for Distance (SL)

As the starting line, a 0.3-meter strip and a 6-meter long - 15-cm wide strip running perpendicularly from the middle of the two strips were drawn. The subjects were informed about how to do the SL test. In the SL test, the participants started to stand on one foot at the marked starting line and, when ready, jumped as far as they could horizontally and fell on the same leg, the result was recorded in cm by detecting the successful attempt between the starting line and the subject's heel level. Before the test, three trial repetitions were made to the subjects. After the trial repetitions, the participant performed 3 main tests and the success criterion in the test was determined as the subjects landing on one leg with full stabilization and staying for three seconds. Between trials, subjects rested for 30 seconds. The use of arm movement during the movement was allowed and no restrictions were made (17).

Crossover Hop for Distance (CHD)

As the starting line, a 0.3-meter strip and a 6-meter-long - 15-cm-wide strip running perpendicularly from the middle of the two strips were drawn. The subjects were informed about how to do the CHD test. The subject stood on one leg at the starting line and performed 3 jumps forward, and the distance jumped was recorded in cm. The first jump started diagonally opposite the foot used and continued laterally to the side of the fall. Three repetitions of trials were made to the subjects for each

test. After the trials, the participant performed 3 main tests and the criterion for success in the test was determined as the subjects landing on the leg with full stabilization and staying for three seconds. The best jump distance was recorded in cm. Between each test, subjects were given a 30-second rest interval (27).

Medial Side Triple Hop for Distance (MSTH)

For the MSTH test, the medial aspect of the participants' feet to be jumped was brought to a perpendicular position to the jumping direction. They were asked to perform three consecutive jumps on the same foot, and the distance of three consecutive jumps was measured as the distance between the medial part of the foot in the starting position and the medial part of the foot in the finishing position. The results were recorded in cm.

Statistical analysis

SPSS 25.0 package program was used in the statistical analysis of our research. Whether the data showed normal distribution was examined with the Shapiro Wilk test and it was determined that the data were normally distributed. The Homogeneity tests were examined by applying Levene's test and it was determined that the variances were homogeneous. The paired sample t-test was used to compare right and left extremities, and One Way ANOVA tests were used for comparisons of three or more groups. Multiple comparisons were examined with the Tukey test. Effect size calculations in binary comparisons were calculated from Cohen's d formula. The data were presented as mean and standard deviation and analyzed at the $p<0.05$ significance level.

Results

In Table 1, the results obtained after SLHTs were applied to the subjects were compared between the right and left extremities. When the results were evaluated, statistical significance was found between the right and left limbs only in the SL test (p=0,014, %95 CI= -10,22 / -1,30) among the SLHTs applied ($p<0.05$). No significance was found in other SLHTs ($p>0.05$).

LSI rates calculated separately from SL, CHD, and MSTH tests were compared in Table 2. When the results were evaluated, it was determined that the LSI values obtained from SLHTs applied in different directions did not reveal a statistically significant difference ($p>0.05$). As a result, the LSI values in different directions were similar in our footballer subjects.

Discussion and Conclusion

In the present study, it was aimed to evaluate the LSI ratios obtained from three different SLHT results applied in football players. In the SL, CHD, and MSTH tests applied to the subject group formed by the football players, the rates of DS and NDS were determined as 97.22%, 99.71%, and 99.19%, respectively, in the LSI evaluations between the groups. Besides,

Table 1. Comparisons of DS and NDS results in SLHTs

	DS	NDS				%95 CI	
Variable (cm.)	**Mean ± Sd**	**Mean ± Sd**	**t**	**p**	**ES**	**LB**	**UB**
SL	196,19±15,54	201,95±14,89	-2,694	0,014*	-0,38	-10,22	-1,30
CHD	601,71±53,52	605,71±59,25	-0,412	0,685	-0,07	-24,24	16,24
MSTH	545,95±59,95	551,00±51,16	-0,537	0,597	-0,09	-24,65	14,56

*p<0,05, SL single leg hop for distance; CHD crossover hop for distance; MSTH medial side triple hop for distance; ES cohen's d effect size; LB lower bound; UB upper bound

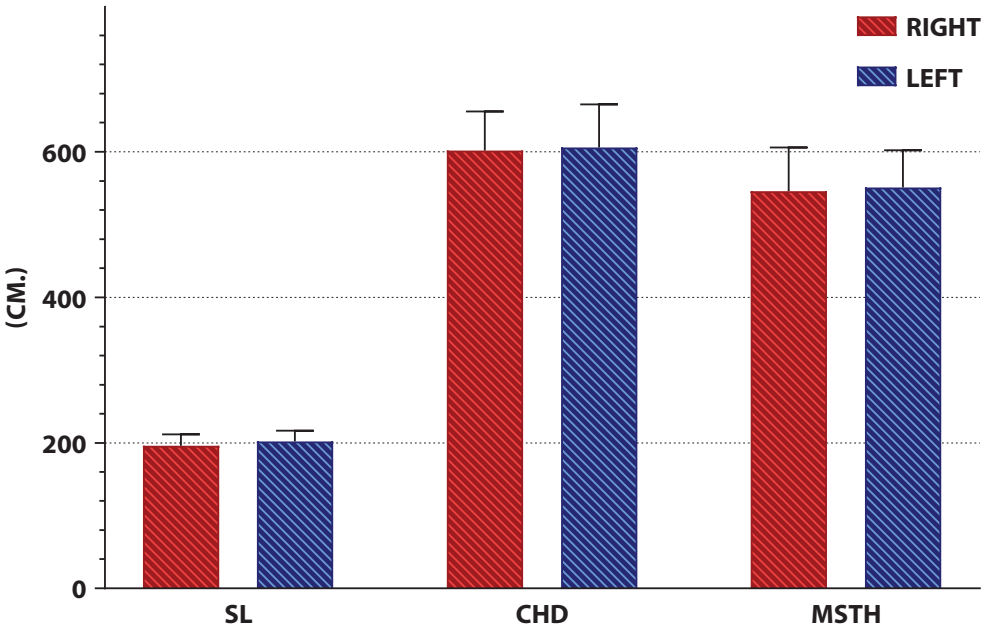

Figure 1. Comparisons of SLHTs between right and left extremities

Table 2. Comparison of LSI rates revealed by subjects as a result of SLHTs

Variables (%)	Mean ± Sd	%95 CI		Min.	Max.	F	p
		LB	UB				
SL	97,22±4,90	94,99	99,45	85,64	104,23	0,780	0,463
CHD	99,71±7,60	96,25	103,17	85,56	117,00		
MSTH	99,19±7,57	95,74	102,63	83,85	115,74		

SL single leg hop for distance; CHD crossover hop for distance; MSTH medial side triple hop for distance; LB lower bound; UB upper bound

only the SL test showed a significant difference in favor of the left side between the 3 SLHTs.

Researchers stated that significant asymmetries may develop in the DS and NDS limbs in athletes belonging to branches that require a constant preference for one leg, especially football, during training or competitions (28, 29). DS and NDS were performed with separate measurements on the sides, and SLHTs were frequently used to detect asymmetries between the extremities (20). Researchers investigated the reliability of these tests with many different studies using SLHTs in subjects with and without a history of disability and reported that they were highly valid and reliable tests (12, 24, 30, 31). In the literature, it was emphasized that SLHTs provide consistent results and predictions regarding the reconstruction procedures performed after anterior cruciate ligament injuries, which were frequently encountered in football players, and the decision-making processes to return to sports (32). On the other hand, Dingenen et al. (2019) examined the asymmetry rates by applying SL, Triple leg hop for distance (THD), and MSTH tests from SLHTs for different groups in their study and found the mean of LSI values to be 100.65% in athletes without a history of injury (33). In another study, Madsen et al. (2020) examined LSI rates in their study with 275 physically active healthy participants and determined LSI rates ranging from 91% to 96% as a result of 6 different SLHTs they applied (34). In their study, Lisee et al. (2019) applied four different SLHTs in their study with 117 healthy subjects who had no history of disability in the last six months and found LSI

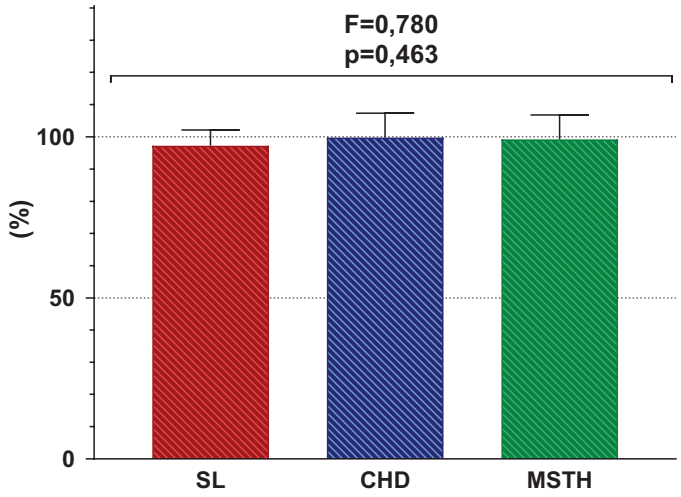

Figure 2. Comparison of LSI rates revealed by subjects in different SLHTs

rates ranging from 94.83% to 96.16% (35). Munro & Herrington (2015) examined limb asymmetries with SLHTs, and they detected asymmetry at a rate of 100.32% and 99.20% in women and men, respectively, as a result of the four applied tests (17). When the LSI rates evaluated with SLHTs were examined in the relevant literature studies, studies with rates of 90% and above were frequently encountered. Moreover, when the LSI rates obtained as a result of our study were examined, it can be evaluated that they were similar to the literature results. Moreover, Capranica et al. (1992) examined the strength differences in the dominant and non-dominant legs in their study on 10-year-old football players and could not detect any difference. Researchers associated this result with the fact that the development of muscle strength to a specific level was not yet occurred due to the age levels of the experimental group (36). Vaisman et al. (2017), on the other hand, applied jump tests to the study group consisting of non-athletes and football players, and they could not detect a significant difference between DS and NDS in both groups (37). When the results of our study were examined, it can be concluded that the LSI rates for the football player group participating in the study showed low asymmetries and the injury risks of the athletes were low. Considering the movement mechanisms of the SLHTs applied in our study, it was important in determining the functional performance differences between the DS and NDS limbs of the subjects. However, especially in sports branches such as football, where the dominant extremities were thought to have higher force production capacities, lower extremity strength differences should not only be limited to measurements between the limbs but also should be evaluated between muscle groups that work in the same limb as agonist and antagonist. With these evaluations, more specific data about strength deficiencies and injury risks can be obtained by analyzing the strength differences towards the lower extremities in football players in a more comprehensive way. Besides, considering that LSI rates may differ in terms of characteristics such as age, height, weight, and gender, it is important to conduct studies on the relevant parameters to analyze this ratio more effectively and to correlate it in terms of different variables.

Conflicts of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

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