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Interlimb Asymmetry and Performance Variables in Female Football Players: Effects on Dynamic Balance, Jump Performance, and Positional Differences

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ABSTRACT

This study aims to investigate the effects of interlimb asymmetry on dynamic balance, vertical and horizontal jump performance in female footballers. The study examined the relationships between the athletes' demographic characteristics such as nationality, position and licensed sports history and their performance values.
The sample group in the study consists of Atasehir women's football players (age 23.36±2.57, BMI 20.99±1.57, licensed sports years 6.68±2.06). The performance measurements of the athletes in the study were measured with Togu Challenge Disc and Jump Mat Pro. It was determined that the measurement data among the athletes were not normally distributed. The relationship differences between the obtained data were determined with the Mann Whitney U test in the SPSS 24.0 program.
While there was a significant difference in the balance difference (%) (t_{20}=2.759; p=0.047) and horizontal jump difference (%) (t_{20}=2.609; p=0.040) values in the test results of the athletes, it was determined that the defensive players were significantly higher than the attackers in both balance and horizontal jump differences. No difference was observed in the performance values in terms of the licensed sports backgrounds of the athletes (p>0.05).
The results of the study showed that the balance levels of foreign football players were significantly higher than those of domestic footballers, while the balance and horizontal jump differences of defensive players were significantly higher than those of offensive players in terms of positions. Positive relationships were found between age, BMI and sports history and performance values. According to these results, it is recommended that individual training plans be made by considering the balance and horizontal jump parameters in the training planning processes of athletes. In this way, athletes can increase individual performance in the game. In addition, these data obtained can be an effective criterion in the selection of players by athletes according to positions.

Keywords: Dynamic Balance, Football, Vertical and Horizontal Jump

INTRODUCTION

The term "limb asymmetry" refers to the function of one limb in relation to the other (i.e., the contralateral upper or lower limbs, etc.) and can be defined as an irregularity or mechanical imbalance (Buchheit & Simpson, 2017; Foster et al., 2017; Halson, 2014). Today, interlimb asymmetry has become an increasingly common research topic, with studies reporting the prevalence of differences during various physical capacity tests (Jones & Bampouras, 2010; Maloney et al., 2017; Newton et al., 2006). When investigating limb or extremity asymmetries, several factors need to be considered when selecting the most suitable test for individuals, such as the reliability of the test, the individuals' needs, and the availability of equipment (Bishop et al., 2017). There are several methods to assess asymmetrical differences, including isokinetic dynamometry (Silva et al., 2015; Ruas et al., 2015), unilateral isometric squats or thigh pull (Dos'Santos et al., 2017; Hart et al., 2012), and jump-based tests (Bishop et al., 2021; Lockie et al., 2014; Loturco et al., 2018; Maloney et al., 2017). These methods have been shown to be sensitive in detecting asymmetrical differences between limbs in both athletes and sedentary individuals (Bishop et al., 2021). In theory, high asymmetry results may lead to lower physical performance, potentially increasing the risk of injury and affecting technical efficiency (Loturco et al., 2018; Chalmers et al., 2018; Chalmers et al., 2017). However, the mere prevalence of asymmetrical differences provides limited information about whether training programs aimed at minimizing these differences are necessary (Bishop et al., 2021). Therefore, in-depth investigation and understanding of interlimb asymmetry is crucial for sports science and practitioners.

Numerous studies have been developed to examine the relationships between different asymmetry measurements and sports performance (Bishop et al., 2018; Lockie et al., 2014; Bini & Hume, 2015; Trivers et al., 2014). Trivers et al. analyzed lower extremity symmetry in 73 elite Jamaican male and female athletes and reported that higher symmetry scores (in knee and ankle characteristics) were positively associated with sprint speed (Trivers et al., 2014). In another study, higher asymmetry scores in pedal force were observed to be related to better 4km time trial performance in cyclists and triathletes (Bini & Hume, 2015). In a different study, Maloney et al. demonstrated that in healthy adult males, higher asymmetry in the unilateral drop jump test was associated with slower change of direction speed performance (Maloney et al., 2017). In contrast, Lockie et al. found no effect of unilateral jump height asymmetry on speed or change of direction speed performance in a male college sample (Lockie et al., 2014).

More specifically, Loturco et al. reported that lower extremity asymmetries identified through three different functional screening assessments (isokinetic strength testing, unilateral vertical jump, and tensiomyography) were not related to impaired jump performance in professional male football players (Loturco et al., 2018). On the other hand, Bishop et al. observed that high asymmetry scores obtained from unilateral vertical jump tests were significantly related to slower sprint times and lower unilateral vertical jump performance in young female football players (Bishop et al., 2021). Previous studies also indicated that athletes with interlimb asymmetries greater than 10% (from unilateral jump tests) were four times more likely to suffer a re-injury of the anterior cruciate ligament than those without such asymmetries (Kyritsis et al., 2016). While the aforementioned studies are informative, they indicate that the exact effects of asymmetry on various aspects of physical performance remain incompletely understood.

Given the limited data on the effects of asymmetry on performance in elite female football players (Maloney et al., 2017), examining the relationship between asymmetry and balance would be valuable. This study is significant as it is the first to investigate the relationship between asymmetry values determined using unilateral vertical and horizontal jump tests and balance in female football players. The aim of this study is to comprehensively explore the relationship between the asymmetry identified through pre-established unilateral vertical and horizontal jump tests and balance in female football players. The findings are expected to shed light on the relationship between asymmetry and balance in these athletes.

METHOD

Research group

In the study, 22 female football players who actively played in the Turkish Football Federation Women's Super League in the 2023-2024 season participated voluntarily. The participants in this study consisted of 22 female football players with the following characteristics: the mean age was 24.32 years (range: 19 to 28 years), the mean height was 163.73 cm (range: 155 to 174 cm), and the mean weight was 56.32 kg (range: 46 to 75 kg). The average body mass index (BMI) was 20.94 kg/m² (range: 18.90 to 24.77 kg/m²). The players had an average of 7.23 years of licensed sports experience, with a minimum of 4 years and a maximum of 10 years.

Method of the Research

This study aims to explore the relationship between limb asymmetry and balance in female football players, utilizing vertical and horizontal unilateral jump tests to measure asymmetry. The methodology consists of the following steps: The study employed a correlational research design, aiming to examine the relationship between asymmetry values obtained from unilateral jump tests and balance performance in female football players. This design is appropriate to analyze how differences in limb strength and performance may correlate with balance capabilities.

Pre-assessment: Prior to testing, participants completed a brief questionnaire detailing their demographic information (age, height, weight, BMI) and years of licensed sports experience. This information was used to provide a descriptive overview of the sample.

Asymmetry Measurement: Asymmetry between the limbs was assessed through two unilateral jump tests: the unilateral vertical jump and the unilateral horizontal jump and dynamic balance. These tests are commonly used in research to evaluate the strength and power output of each limb individually (Bishop et al., 2021; Lockie et al., 2014). During these tests, each participant was instructed to perform three trials on both the dominant and non-dominant legs, and the highest recorded jump height or distance was used for analysis.

The study adhered to ethical guidelines for research involving human participants. All participants provided informed consent before participation, ensuring that they understood the purpose of the study, the tests involved, and their right to withdraw at any time without penalty.

Measurements

Anthropometric Measurements

The participants' height was measured using a portable stadiometer (Seca 213, Hamburg, Germany) with an accuracy of 0.01 meters, while body weight was measured with an electronic scale (Tanida DC 360) with a precision of 0.1 kg.

Warm-Up and Exercise Protocol Design

The warm-up and exercise protocol in this study was completed through a series of exercises performed before the test day, including jogging-dynamic stretching, jogging-dynamic stretching-resistance band exercises, and jumping movements (Christensen et al., 2020). After providing detailed pre-test instructions, the warm-up and exercise protocol was applied to the participants. All measurements were conducted during the competition period, and the participants had been engaged in regular training since the beginning of the season.

Dynamic Balance Test

Dynamic balance was assessed using a portable dynamic balance tool, the Togu Challenge Disc (2.0, Prien am Chiemsee, Rosenheim, Germany). The device utilizes 3D sensors to detect movements made by the athlete to maintain balance on the disc, which are then transmitted in real-time to a tablet or smartphone via Bluetooth. During the test, participants were instructed to perform the test barefoot to eliminate any potential influence of socks or shoes on the results. The tester stood in front of the platform, ensuring that the athlete could view the screen easily during the test. The athlete was required to maintain the center of the circle on the screen for 20 seconds. The test began after a 5-second countdown, with the athlete trying to hold the balance by following the instructions on the tablet. The measurement platform was placed on a flat surface to prevent any flexing due to the ground. The test was repeated twice after a 3-minute passive rest, and the best score from the two trials was recorded. Dynamic balance measurements were performed in three positions: double-leg stance, right single-leg stance, and left single-leg stance. The limb symmetry index (LSI) was used to determine the difference between the limbs following the single-leg balance measurements.

Vertical Jump-Reactive Strength Test

Vertical jump and reactive strength tests were conducted using the Jump Mat Pro device, which has been validated for reliability in previous studies. Before testing, athletes were given detailed instructions. The test began with a double-leg vertical jump, where participants positioned themselves with their hands on their hips, their body straight, and facing forward. They then bent their knees and jumped as high as possible. Subsequently, the vertical jump tests were performed for the right and left legs using the same protocol. The athletes' jump heights were recorded in real-time on a tablet application, and the best score from two attempts was recorded. After the single-leg jump measurements, the limb symmetry index (LSI) was used to calculate the difference between the two limbs.

Long Jump Test

The long jump measurements were recorded using a prepared measuring tape, with data recorded in centimeters. The long jump was performed in three variations: double-leg, right single-leg, and left single-leg jumps. After completing the single-leg jump tests, the limb symmetry index (LSI) was used to determine the difference between the two limbs.

Analysis of Data

Data analysis was performed using the JASP 0.16.4 statistical software. Descriptive statistics, including means, standard deviations, minimum, and maximum values, were calculated for variables such as age, BMI, sports history, and performance parameters (balance, vertical jump, horizontal jump). Independent samples t-tests were conducted to compare performance parameters based on nationality (domestic vs. foreign) and playing position (defense vs. offense). One-way ANOVA was used to examine differences in performance parameters according to sports history (years), with post-hoc tests applied where significant differences were found. Pearson correlation analysis was performed to investigate relationships between age, BMI, sports history, and performance parameters, as well as the relationships among performance variables. Significance was set at $p<0.05$, and Levene's test was used to check the assumption of equality of variances when necessary.

FINDINGS

Table 1. Distribution of female football players according to their individual characteristics

Variable	Group	n	%
Nationality	Domestic	13	59,09
	Foreign	9	40,91
Year of Licensed Sport	5 years and under	7	31,82
	6-7 years	5	22,73
	8 years and over	10	45,45
Position	Attack	9	40,91
	Defense	13	59,09

It was determined that 59.09% of female football players were local, 40.91% were foreign, 31.82% were 5 years or less, 22.73% were between 6-7 years, 45.45% had a sports history of 8 years or more, 40.91% were attackers and 59.09% were defensive players.

Table 2. Comparison of performance levels of female football players according to their nationality

Variables	Nationality	N	X	Std	t	p
Dominant Leg Vertical Jump	Domestic	13	17,82	2,38	-0,565	0,578
	Foreign	9	18,46	2,86		
Non-Dominant Leg Vertical Jump	Domestic	13	18,25	2,97	0,012	0,990
	Foreign	9	18,23	1,17		
Vertical Jump % Difference	Domestic	13	8,78	13,54	0,074	0,942
	Foreign	9	8,42	6,90		
Dominant Leg Balance	Domestic	13	3,94	0,54	-2,621	**0,016***
	Foreign	9	4,55	0,54		
Non-Dominant Leg Balance	Domestic	13	3,73	0,55	-3,529	**0,002****
	Foreign	9	4,48	0,37		
Balance % Difference	Domestic	13	10,23	7,82	1,728	**0,032***
	Foreign	9	5,22	4,47		
Dominant Leg Horizontal Jump	Domestic	13	1,61	0,12	-0,514	0,613
	Foreign	9	1,64	0,14		
Non-Dominant Leg Horizontal Jump	Domestic	13	1,63	0,12	0,999	0,330
	Foreign	9	1,57	0,13		
Horizontal Jump % Difference	Domestic	13	4,01	2,76	-1,413	0,173
	Foreign	9	6,40	5,16		

*=p<0.05

In Table 2, independent sample T-test was applied at α=0.05 significance level to determine whether there was a significant difference in the performance values of female football players in terms of their nationalities. The test results showed that there were significant differences in dominant leg balance (t_{20}=-2,621; p=0,016), non-dominant leg balance (t_{20}=-3,529; p=0,002) and balance difference (%) (t_{20}=1,728; p=0,032). In balance levels, it was determined that the averages of foreign footballers were significantly higher than the averages of local footballers. No significant difference was observed in other performance values.

Table 3. Comparison of performance levels of female football players according to their positions

Variables	Position	N	X	Std	t	p
Dominant Leg Vertical Jump	Attack	9	18,22	2,33	0,211	0,835
	Defense	13	17,98	2,76		
Non-Dominant Leg Vertical Jump	Attack	9	18,93	3,17	1,156	0,261
	Defense	13	17,76	1,54		
Vertical Jump % Difference	Attack	9	12,22	15,01	1,283	0,214
	Defense	13	6,15	6,96		
Dominant Leg Balance	Attack	9	4,19	0,65	0,017	0,087

	Defense	13	4,19	0,60		
Non-Dominant Leg Balance	Attack	9	3,95	0,69	-0,539	0,096
	Defense	13	4,09	0,57		
Balance % Difference	Attack	9	9,56	6,88	2,759	**0,047***
	Defense	13	7,23	7,19		
Dominant Leg Horizontal Jump	Attack	9	1,65	0,11	0,858	0,064
	Defense	13	1,60	0,14		
Non-Dominant Leg Horizontal Jump	Attack	9	1,61	0,12	0,240	0,053
	Defense	13	1,60	0,13		
Horizontal Jump % Difference	Attack	9	5,62	5,22	2,609	**0,040***
	Defense	13	4,55	3,04		

*=p<0.05

In Table 3, independent sample T-test was applied at α=0.05 significance level to determine whether there was a significant difference in the performance values of female football players in terms of their positions. The test results showed that there were significant differences in balance difference (%) (t20=2,759; p=0,047) and horizontal jump difference (%) (t20=2,609; p=0,040). In both balance and horizontal jump differences, the mean values of defence players were significantly higher than the mean values of offence players. There was no significant difference in other performance values.

Table 4. Comparison of performance levels of female football players according to sports years

Variables	Year of Licensed Sport	N	X	Std	F	p
Dominant Leg Vertical Jump	5 years and under	7	18,06	2,6	0,13	0,879
	6-7 years	5	17,6	3,6		
	8 years and over	10	18,34	2,13		
Non-Dominant Leg Vertical Jump	5 years and under	7	17,84	1,87	0,498	0,615
	6-7 years	5	17,68	1,37		
	8 years and over	10	18,8	3,02		
Vertical Jump % Difference	5 years and under	7	2,01	3,56	2,018	0,16
	6-7 years	5	11,18	8,12		
	8 years and over	10	11,99	14,1		
Dominant Leg Balance	5 years and under	7	3,93	0,68	0,95	0,404
	6-7 years	5	4,34	0,66		
	8 years and over	10	4,3	0,53		
Non-Dominant Leg Balance	5 years and under	7	3,92	0,55	0,908	0,42
	6-7 years	5	4,36	0,44		
	8 years and over	10	3,95	0,7		
Balance % Difference	5 years and under	7	8,86	8,05	0,242	0,787
	6-7 years	5	6,2	5,85		
	8 years and over	10	8,7	7,27		
Dominant Leg Horizontal Jump	5 years and under	7	1,58	0,12	0,674	0,522
	6-7 years	5	1,63	0,18		
	8 years and over	10	1,65	0,11		
Non-Dominant Leg Horizontal Jump	5 years and under	7	1,63	0,12	0,184	0,833
	6-7 years	5	1,59	0,14		
	8 years and over	10	1,59	0,13		
Horizontal Jump % Difference	5 years and under	7	3,29	2,45	1,066	0,364
	6-7 years	5	6,53	1,08		
	8 years and over	10	5,4	5,37		

*=p<0.05

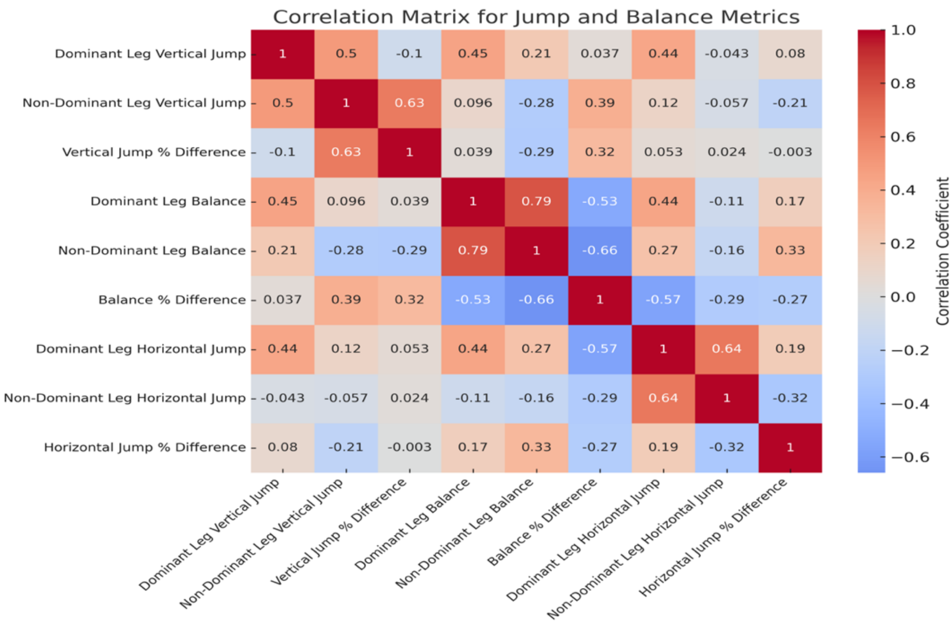
In Table 4, One-way ANOVA test was applied at α=0.05 significance level to determine whether there was a significant difference in the performance values of female football players in terms of their licensed sports history. The test results showed that there was no significant difference in performance values.

Table 5. Evaluation of the relationship between age, BMI and sports history and performance of female football players

Variables		Dominant Leg Vertical Jump	Non-Dominant Leg Vertical Jump	Vertical Jump % Difference	Dominant Leg Balance	Non-Dominant Leg Balance	Balance % Difference	Dominant Leg Horizontal Jump	Non-Dominant Leg Horizontal Jump	Horizontal Jump % Difference
Age	r	-0,059	0,097	**,475***	0,35	0,035	-0,03	0,168	-0,06	0,225
	p	0,793	0,667	0,025	0,11	0,877	0,894	0,455	0,79	0,315
BMI	r	**,567****	0,164	0,033	0,317	0,264	-0,027	**,446***	0,133	0,171
	p	0,006	0,465	0,883	0,151	0,236	0,907	0,038	0,556	0,446
Year of Licensed Sport	r	0,023	0,159	**,443***	0,291	0,004	0,017	0,239	-0,064	0,212
	p	0,917	0,479	0,039	0,189	0,985	0,939	0,285	0,776	0,344

*=p<0.05

In Table 5, Pearson correlation test was performed at α=0.05 significance level to determine whether the athletes' age, BMI and sport history were related with their performance values. The test results showed that there was a positive correlation between age and vertical jump difference (%) (r=0.475; p=0.025), a positive correlation between BMI and dominant leg vertical jump (r=0.567; p=0.006) and dominant leg horizontal jump (r=0.446; p=0.038), and a positive correlation between licensed sports history and vertical jump difference (%) (r=0.443; p=0.039).



Graphic 1. Evaluation of the relationship between performance values of female football players

In Graph1, Pearson correlation test was applied at α=0.05 significance level to determine whether the performance values of female footballers were related. The test results showed that there was a positive correlation between dominant leg vertical jump and dominant leg balance (r=0,449; p=0,036) and dominant leg horizontal jump (r=0,436; p=0,042), a positive correlation between dominant leg balance and dominant leg horizontal jump (r=0,437; p=0,042), and a negative correlation between balance difference and dominant leg horizontal jump (r=-0,569; p=0,006).

DISCUSSION AND CONCLUSION

The aim of the study was to examine the effects of inter-limb asymmetry on dynamic balance, vertical, and horizontal jump performance in female football players. Differences in players' nationality, position, licensed sports background, and performance were identified in the study.

The results showed that the mean age of female football players was 23.36±2.5 years, their BMI was 20.99±1.57, and their average sports background was 6.68±2.06 years. Additionally, it was found that 59.09% of the players were domestic, while 40.91% were foreign; 31.82% had less than or equal to 5 years of sports background, 22.73% had between 6 and 7 years, and 45.45% had more than 8 years.

Regarding playing positions, 40.91% of the players were offensive players, and 59.09% were defensive players.

When examining the performance values based on nationality, significant differences were observed in dominant leg balance (t20=-2.621; p=0.016), non-dominant leg balance (t20=-3.529; p=0.002), and balance difference (%) (t20=1.728; p=0.032). It was determined that foreign players had significantly higher balance averages than domestic players, which may be attributed to the developmental stage of women's football in the country. No significant differences were observed in the other performance values. A study in the literature revealed that national-level players exhibited better balance values than regional-level players (Paillard et al., 2006).

Regarding performance evaluation results based on playing positions, significant differences were observed in balance difference (%) (t20=2.759; p=0.047) and horizontal jump difference (%) (t20=2.609; p=0.040). Defensive players had significantly higher averages than offensive players in both balance and horizontal jump differences. These findings align with studies by Arnason et al. (2004) and Carling et al. (2012), which suggest that anthropometric differences likely exist among positions. However, no significant differences were found in players' other performance values. Gil et al. (2007) stated that football players exhibit different physical and motor characteristics based on their positions, and these differences align with workload demands on the field. Sutton et al. (2009) similarly concluded that there are significant anthropometric differences among positions in their study on young professional athletes. Aughey Wyckels et al. (2010) reported the average vertical jump values of Australian female midfield players as 45.5 ± 0.13 cm. Aktas et al. (2020) investigated performance parameters based on positions in football players and found no significant relationships in vertical jump and agility values across positions. These findings were similar to those of the current study. However, Erdem et al. (2015) found no differences in balance values based on positions in their study, contrasting with the findings of the current research.

When examining performance values based on licensed sports backgrounds, no significant differences were observed. To determine whether the players' age, BMI, and sports background were related to performance values, Pearson correlation tests were applied at a significance level of α=0.05. The test results showed positive relationships between age and vertical jump difference (%) (r=0.475; p=0.025), BMI and dominant leg vertical jump (r=0.567; p=0.006), BMI and dominant leg horizontal jump (r=0.446; p=0.038), and licensed sports background and vertical jump difference (%) (r=0.443; p=0.039). Uzun (2016) identified significant differences between the sports age and vertical jump performance of female football players. Although the positive relationship between licensed sports age and vertical jump difference may be an age-related effect, further studies are needed to confirm this.

Thomas et al. (2012) examined the speed and vertical jump values of elite female football players, reporting an average vertical jump value of 30.7 ± 4.1 cm. Similarly, Castagna et al. (2012) found the vertical jump values of female football players to be 29.1 ± 3.3 cm. Krustrup et al. (2010) investigated match-induced fatigue levels in elite female players, reporting pre- and post-match vertical jump values of 36 ± 1 cm and 31 ± 4.3 cm, respectively. Studies on young female athletes revealed greater asymmetry in vertical jump compared to horizontal jump (Bishop et al., 2021; Lockie et al., 2014). Consistent with this, Bishop et al. (2021) found asymmetry values of 12.5% in single-leg vertical jump and 6.8% in single-leg horizontal jump among elite young female football players.

Table 6 presents the relationships between performance values. A positive relationship was found between dominant leg vertical jump and dominant leg balance (r=0.449; p=0.036) as well as dominant leg horizontal jump (r=0.436; p=0.042). Additionally, a positive relationship was observed between dominant leg balance and dominant leg horizontal jump (r=0.437; p=0.042), while a negative relationship was found between balance difference and dominant leg horizontal jump (r=-0.569; p=0.006). The results of this study contrast with findings from previous research (e.g., Bishop et al., 2019; Loturco et al., 2019), which reported no significant relationships between asymmetry parameters in female football players. Similarly, Pardos-Mainer et al. (2021) found no significant relationships among asymmetry outcomes in adult female football players. These discrepancies suggest the need for larger and more comprehensive studies to better understand these findings. Hadda et al. (2023) investigated the relationships between dominant and non-dominant legs in elite football players and found no significant differences in vertical jump heights between the two legs.

The findings of this research indicate a strong relationship between balance and horizontal jump differences among defensive and offensive players. Based on these results, it can be suggested that players exhibit different performance parameters according to their positions.

In conclusion, it is recommended that balance and horizontal jump parameters be considered in the training planning processes of athletes, with individualized training programs tailored accordingly.

This approach may enhance players' individual performances during games. Additionally, these findings could serve as effective criteria for player selection based on their positions.

RECOMMENDATIONS

Future research should focus on conducting more comprehensive and longitudinal studies to better understand the impact of inter-limb asymmetry on performance parameters such as balance, vertical jump, and horizontal jump. Expanding sample sizes, including players from diverse levels of competition and regions, will provide broader insights into the findings and help generalize the results to a wider population of female football players. Additionally, biomechanical analyses and advanced imaging techniques could be used to explore the underlying mechanisms of asymmetry and its relationship with injury risk, performance, and rehabilitation.

Studies investigating the relationship between inter-limb asymmetry and specific playing positions are also encouraged. This approach can help to further clarify how positional demands influence balance and jumping performance in female football players. It would also be beneficial to explore the role of training history, fatigue levels, and game-specific activities in inter-limb asymmetry to identify potential intervention points.

By implementing these recommendations, female football players can enhance their performance, reduce the risk of injuries, and contribute to the development of women's football at both the individual and team levels.

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