

ORIGINAL RESEARCH

Positional differences in interlimb asymmetry in elite youth male futsal players

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Abstract

Background: Interlimb asymmetry has been associated with increased injury risk and impaired performance in athletes. **Objective:** This study aimed to analyse positional differences in interlimb asymmetry and unilateral functional performance among elite male youth futsal players. **Methods:** Eighty-three youth futsal players (age 17.2 ± 0.8 years) were assessed according to playing position (right/left winger, pivot, defender). Participants performed unilateral countermovement jump (CMJ), horizontal jump (HJ), and the 505 change of direction (COD 505) tests. Interlimb asymmetry was calculated for each test. One-way analysis of variance was used to compare asymmetry levels across positions. Pearson's correlations were computed to explore relationships between test-specific asymmetries. Players were also classified into high ($\geq 10\%$) or low ($< 10\%$) asymmetry groups, and Chi-square tests were applied to assess associations with position. **Results:** No significant differences in interlimb asymmetry were observed between positions in CMJ ($p = .61$), HJ ($p = .13$), or COD 505 ($p = .26$), though HJ showed greater variability ($\eta^2 = .07$). A significant correlation was found between CMJ and HJ asymmetries ($r = .31, p < .001$), suggesting shared neuromuscular demands. No association was found between asymmetry level and position in CMJ, HJ or COD 505. Additionally, 38.9% of pivots and 40.7% of right wingers exceeded the 10% asymmetry threshold in CMJ. **Conclusions:** Although interlimb asymmetries did not significantly differ across positions, the presence of asymmetries $\geq 10\%$ in a notable proportion of players highlights the relevance of individualised monitoring in youth futsal. These findings support the use of asymmetry assessments as part of injury prevention strategies in elite and developmental settings.

Keywords: team sport, injury prevention, futsal, asymmetry, youth athletes

Introduction

Futsal is an intermittent team sport that imposes high physiological, physical, tactical, technical, and psychological demands, requiring players to perform repeated short intervals of high-intensity effort throughout the game (Barbero-Alvarez et al., 2008; Spyrou et al., 2020). Matches are characterized by frequent high-intensity actions such as repeated sprints, accelerations, decelerations, change of direction (COD), and braking actions, interspersed with brief rests that result in constant incomplete recoveries (Ribeiro et al., 2020). The game is played on a reduced playing area (40×20 m) with 3×2 m goals, where two teams compete with five players on the court (one goalkeeper and four outfield players; Naser et al., 2017). In addition, the regulations allow teams to register up to fourteen players per match and make unlimited substitutions, which helps maintain game intensity throughout the 40 min of play and increases both the physical and tactical demands of competition (Illa, Alonso, et al., 2021; Ribeiro et al., 2021).

The dynamics of futsal are organized around specific playing positions: goalkeeper, defender, winger, and pivot (Caetano et al., 2015). Although the overall demands tend

to be relatively homogeneous among outfield players, since rotations across positions are frequent, each role maintains certain particular characteristics (Sekulic et al., 2019). All outfield positions (defender, winger, and pivot) cover comparable relative distances per minute during match play (91 ± 9 m, 86 ± 6 m, and 95 ± 10 m in the first half; 92 ± 12 m, 86 ± 9 m, and 92 ± 9 m in the second half, respectively; Serrano et al., 2020). Defenders play a key defensive role against the opposing pivot, engaging in more high-intensity duels when their team is out of possession, while performing fewer off-ball efforts than wingers (Ohmuro et al., 2020). Wingers are typically the most physically demanding position, combining a higher number of sprints, dribbles, and defensive coverages, and covering more distance at high intensity (Illa, Alonso, et al., 2021; Illa, Fernandez, et al., 2021; Ohmuro et al., 2020; Serrano et al., 2020). Pivots act as offensive references, with less exposure to high-intensity running but a greater involvement in physical duels during offensive phases compared with other positions (Gadea-Uribarri et al., 2025; Serrano et al., 2020). In this regard, the diverse physical efforts associated with each position may contribute to

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the development of position-specific interlimb asymmetry profiles.

Interlimb asymmetries have been widely associated with both increased injury risk and reduced physical performance, making their identification and monitoring essential for injury prevention and performance optimization in team sports (Fox et al., 2023; Sun et al., 2025). In futsal, this issue may be particularly relevant given the predominance of unilateral high-intensity actions such as accelerations, decelerations, COD, and shooting, which inherently load the lower limbs asymmetrically. The repetitive and explosive nature of these movements, combined with the cumulative exposure to long competitive seasons involving extensive hours of training and match play, may exacerbate the development of functional imbalances between limbs (Rabelo et al., 2016). Consequently, understanding how these asymmetries emerge and manifest in futsal players is important to designing targeted training and prevention strategies that help sustain performance while reducing the likelihood of injury.

In recent years, research in futsal has experienced substantial growth, particularly in the analysis of competitive demands and load monitoring, mainly external load, facilitated by the emergence of new technologies adapted to indoor environments (Albalad-Aiguabella, Mainer-Pardos, Casajús, et al., 2025; Ribeiro et al., 2025). These advances have enabled the tracking of numerous kinematic variables, such as total distance covered, high-speed running (12.1–18.0 km/h), and sprints (>18 km/h), as well as mechanical variables, including the number of high-intensity accelerations and decelerations (Gadea-Uribarri et al., 2025; Ribeiro et al., 2025; Sanchez-Sanchez et al., 2024). These metrics provide objective evidence of the growing intensity of futsal and highlight the increasing prevalence of high-intensity, predominantly unilateral actions throughout match play, which may in turn accentuate interlimb asymmetries among players. To prevent injuries and optimize performance, it is essential to incorporate tests that assess players' physical capacities and identify potential interlimb asymmetries (Bishop, Turner, & Read, 2018). These imbalances, particularly when exceeding 10–15%, have been associated with a higher risk of injury and diminished athletic performance (Guan et al., 2022; Lin et al., 2022). In futsal, unilateral tests that replicate sport-specific actions are commonly used for their detection, such as the single-leg countermovement jump (CMJ), the horizontal jump (HJ), and the 505 change of direction test (COD 505; Oliveira et al., 2025; Sekulic et al., 2019). These individualized assessments provide key information for designing training programs that are more closely aligned with the physical and positional demands (Ribeiro et al., 2025).

In futsal, several studies have documented the presence of functional interlimb asymmetries. López-Fernández et al. (2020) reported that sub-elite players exhibited differences in fat mass and muscle contraction times between the dominant and non-dominant legs. An observational study in official matches found that players used their dominant leg more frequently and with greater accuracy in technical actions such as passing and shooting (Palucci Vieira et al.,

2021). Nunes et al. (2018) observed that 50% of elite futsal players displayed strength imbalances during the preseason. In a study involving Brazilian players, shots executed with the non-dominant leg showed lower ball and foot velocity, reduced accuracy, and distinct joint adjustments (Barbieri et al., 2015). Raya-González et al. (2020) reported that asymmetries did not negatively affect physical performance in elite youth players; however, their results demonstrated that these imbalances were task-specific and not correlated across tests. These findings emphasize the need to employ multiple unilateral tests to individualize player assessment and provide a comprehensive understanding of each athlete's asymmetry profile.

Many fundamental futsal actions are executed unilaterally, which may lead players to develop interlimb asymmetries. This issue is of practical importance, as large between-limb asymmetries have been associated with reduced athletic performance and a higher risk of injury in young athletes. However, research on interlimb asymmetries in youth futsal players remains limited, representing a notable gap in the literature. Therefore, the aim of this study was to analyse the interlimb asymmetry in unilateral CMJ, single-leg HJ, and COD 505 tests across playing positions (right winger, left winger, pivot, defender) in elite male youth futsal players. Additionally, the study examined how many players exhibited high ($\geq 10\%$) or low ($< 10\%$) asymmetry in each test according to their position. It was hypothesized that interlimb asymmetries would differ between positions due to the specific physical demands of each role.

Methods

Participants

A total of 83 male youth futsal players participated in this study (age 17.2 ± 0.8 years; TIER 3; McKay et al., 2021). Goalkeepers were excluded from this study due to the specificity of their role and their distinct physical demands compared to outfield players (Serrano et al., 2020). All players competed in the national U19 top division in Spain and had more than three years of structured futsal training and competitive experience. Their weekly training routines consisted of four to five hours of team-based futsal practice, supplemented by one official match per week. Players were recruited from eight clubs competing in the same national category. Recruitment was carried out by contacting the coaching staff of each club, who were informed about the aims and procedures of the study.

A post hoc power analysis was conducted using G*Power software (Version 3.1.9.3; <https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower>) to verify the adequacy of the sample size. Assuming a one-way analysis of variance (ANOVA) with four groups, a medium effect size ($f = .25$), and a significance level of .05, the total sample of 83 participants yielded a statistical power of .91.

The study received approval from the regional ethics committee (CEICA, Zaragoza, Spain; reference C.P.–C.I PI24/137, act n°07/2024) and was conducted in accordance with the principles of the Declaration of Helsinki.

All players provided written informed consent, and in the case of minors, consent was additionally obtained from their parents or legal guardians.

Study design

This study employed an observational, descriptive, and cross-sectional design with the aim of analyzing interlimb asymmetry differences according to playing position in youth futsal players. Participants were classified based on their habitual playing position into four groups: right winger, left winger, pivot, and defender. All assessments were conducted at the beginning of the regular season, and all players met the following inclusion criteria: (1) active participation in the national U19 top division, (2) being an outfield player, and (3) having a minimum of three years of structured training and competition experience. Players were excluded if they had sustained any musculoskeletal injury in the month prior to testing. Data were collected from three unilateral physical performance tests: the CMJ, the HJ, and the COD 505. These assessments were selected for their ability to detect potential functional imbalances between lower limbs. From the recorded values in each test, interlimb asymmetry percentages were calculated using a standardized formula. Subsequently, asymmetry levels were compared across the different playing positions. Descriptive data and measurement reliability are presented in [Table 1](#).

Procedures

All assessments were conducted indoors in a sports hall, during the afternoon (19:00–21:00), under controlled environmental conditions (temperature 20–24 °C). Data collection took place at the beginning of the competitive season, and all players were previously familiarized with the evaluation procedures. Additionally, participants arrived in a rested and hydrated state, avoiding high-intensity training and caffeine consumption during the preceding 48 hours.

Players performed a standardized 15-min warm-up following the Raise, Activate, Mobilize, and Potentiate (RAMP) protocol, incorporating progressive physiological activation, targeted muscle activation, dynamic mobility exercises, and sport-specific high-intensity drills to prepare players for the testing demands (Jeffreys, 2007). Subsequently, the tests were performed in the following order: unilateral CMJ, unilateral HJ, and COD 505. Clear standardized instructions

were provided to ensure maximal effort in all trials. To avoid potential evaluator bias, all tests were administered and supervised by the same researcher (author O. V.-G.). For the jump tests, three attempts were performed per leg, and for the COD test, two attempts per side were executed, with the best valid result retained for analysis. All assessments started with the left leg to maintain consistency.

The unilateral CMJ was performed using the My Jump 2 application (Version 4.5.5; <https://apps.apple.com/app/my-jump-2/id1148617550>), following a standardized protocol (Bishop et al., 2022). Players started from an upright position with their hands placed on their hips to avoid arm swing, executed a rapid flexion of the knee and hip to approximately 90°, and performed a vertical jump using a single leg. Each participant completed three trials per leg, with 45 s of rest between jumps to minimize fatigue. Jump height (in centimeters) was recorded, and the best attempt for each leg was used to calculate interlimb asymmetry.

The unilateral HJ was assessed over three trials per leg, with free arm movement permitted. Players started from a static position and jumped forward, taking off with one leg. The distance achieved was measured from the take-off line to the nearest heel at the landing point using a measuring tape. A 45-s passive recovery was provided between trials. The best result for each leg was used for the analysis of interlimb asymmetries.

The COD 505 test was used to assess interlimb asymmetry in CODanges of directions performance. Players started from a two-point staggered stance positioned 0.5 m behind the first timing gate (Witty; Microgate). They sprinted 5 m forward, planted and turned 180° on one leg, and then sprinted 5 m back to the start/finish line. Each player completed two trials per leg, with a 2-min recovery between repetitions. The best time for each leg was used to calculate interlimb asymmetry.

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics software (Version 28; IBM). The significance level was set at $p < .05$. Data normality was assessed using the Shapiro-Wilk test, and homogeneity of variances was verified using Levene's test. All variables met the assumptions required for parametric testing; therefore, parametric tests were used throughout the analyses. To compare interlimb

Table 1 Descriptive characteristics and reliability outcomes of physical performance tests

Variable	Mean	SD	CV (%)	ICC	Asymmetry (%)
Age (years)	17.2	0.8			
Height (cm)	175.6	5.8			
Weight (kg)	68.3	8.4			
CMJ L (cm)	18.94	2.81	4.8	.93	8.1
CMJ R (cm)	18.77	2.78	2.9	.96	
HJ L (cm)	185.02	11.01	1.8	.91	3.9
HJ R (cm)	183.58	10.07	2.1	.93	
COD 505 L (s)	2.61	0.09	1.3	.94	3.1
COD 505 R (s)	2.62	0.11	0.9	.89	

Note. CV = coefficient of variation; ICC = intraclass correlation coefficient; CMJ L, CMJ R = unilateral countermovement jump with left or right leg; HJ L, HJ R = unilateral horizontal jump with left or right leg; COD 505 L, COD 505 R = 10 m shuttle sprint with one change of direction to right or left.

asymmetry (%) between playing positions in the three physical performance tests, a one-way analysis of variance (ANOVA) was conducted. To examine the relationships between asymmetries across tests, Pearson's correlation coefficients were calculated. All ANOVA and correlation assumptions were met before conducting the analyses. Players were classified as having high ($\geq 10\%$) or low ($< 10\%$) interlimb asymmetry in each test (Parkinson et al., 2021). The association between asymmetry level and playing position was analysed using the Chi-square test (χ^2). Cramér's V was calculated as a measure of effect size. All descriptive results are presented as mean \pm standard deviation. Finally, to compare performance between the dominant and non-dominant leg for each test, paired-samples t -tests were used. Interlimb asymmetries were expressed as percentages and calculated using the following equation (Bishop, Read, et al., 2018):

$$\text{Interlimb asymmetry} = |\text{Right} - \text{Left}| / \text{Max}(\text{Right}, \text{Left}) * 100.$$

Results

In the CMJ test, mean asymmetry values ranged from 7.28% (defenders) to 9.35% (right wingers). However, the ANOVA revealed no significant differences between positions (Table 2), $F(3, 79) = 0.68, p = .60$, with a small effect size. In the HJ test, the highest asymmetry values were observed in defenders (4.68%) and right wingers (4.5%), whereas the lowest were found in left wingers (2.43%). The ANOVA did not reach statistical significance, $F(3, 79) = 1.81, p = .13$. Nonetheless, the effect size was slightly larger. In the COD test, asymmetry values ranged from 2.2% (defenders) to 3.81% (pivots). No significant differences were found between positions, $F(3, 79) = 1.34, p = .26$, with a small effect size (Table 2).

A positive and significant correlation was found between CMJ asymmetry and HJ asymmetry ($r = .31, p < .001$). No significant correlations were found between CMJ asymmetry and COD asymmetry ($r = -.08, p = .46$),

nor between HJ asymmetry and COD asymmetry ($r = .04, p = .66$).

Figure 1 shows the distribution of players classified with high ($\geq 10\%$) and low ($< 10\%$) interlimb asymmetry in each test (CMJ, HJ, COD), according to playing position. In the CMJ test, the percentage of players with high asymmetry was higher among pivots (38.9%) and right wingers (40.7%) compared to left wingers (31.3%) and defenders (27.3%). However, the Chi-square test revealed no significant association between positions, $\chi^2(3) = 1.31, p = .85$. In the HJ test, most players exhibited asymmetry values below 10%, with only two cases of high asymmetry observed among right wingers. The association between asymmetry and position was not statistically significant, $\chi^2(3) = 8.84, p = .06$, Cramér's $V = .30$. In the COD 505, all players displayed asymmetry values below 10%, except for two isolated cases among right wingers and one pivot. No significant association was observed between playing position and asymmetry category, $\chi^2(3) = 3.77, p = .43$, Cramér's $V = .19$.

Discussion

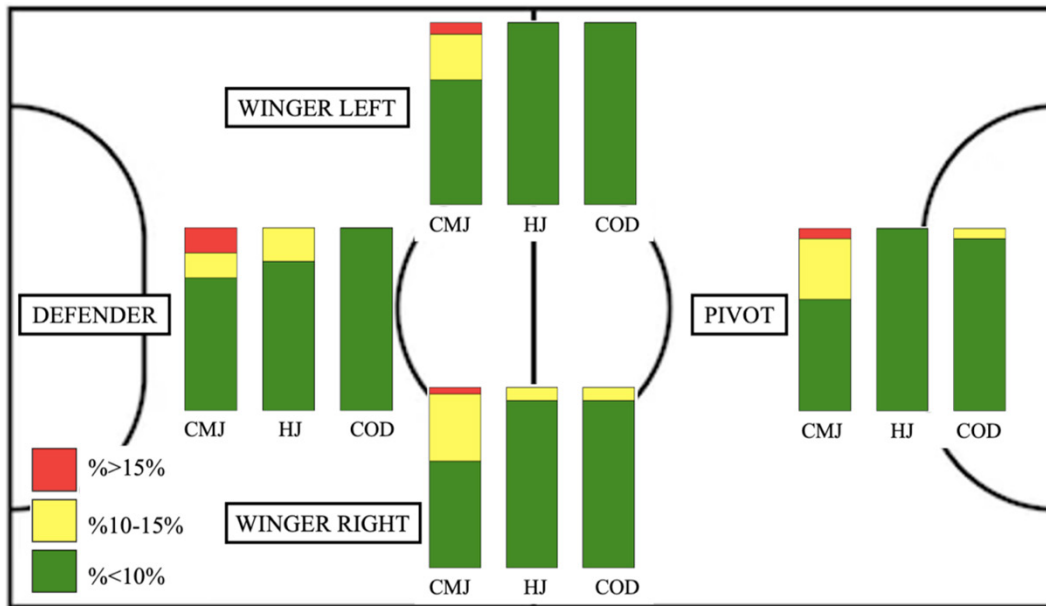
The results of this study revealed that interlimb asymmetry in CMJ, HJ, and COD did not differ significantly across playing positions. However, the highest CMJ asymmetry values were observed in right wingers and pivots, and the lowest in defenders and left wingers. In contrast, asymmetry in HJ and COD remained consistently low across all positions. Correlation analysis showed a significant relationship between CMJ and HJ asymmetry. In contrast, no significant associations were found between COD and either of the jump tests, suggesting that COD asymmetry represents a distinct physical quality. Additionally, the distribution analysis indicated that high asymmetry ($\geq 10\%$) was more prevalent in the CMJ test, particularly among wingers and pivots, while nearly all players demonstrated low asymmetry ($< 10\%$) in HJ and COD.

Table 2 Descriptive statistics and results of one-way analysis of variance for interlimb asymmetry (%) in physical performance tests by playing position

Test/Position	Mean	SD	<i>F</i>	<i>p</i>	η^2 [95% CI]
CMJ			0.68	.60	.03 [.00, .08]
Winger right	9.35	5.33			
Winger left	7.49	6.95			
Pivot	7.70	5.01			
Defender	7.28	5.50			
HJ			1.81	.13	.07 [.00, .16]
Winger right	4.50	3.34			
Winger left	2.43	2.34			
Pivot	3.59	2.21			
Defender	4.68	4.15			
COD 505			1.35	.26	.06 [.00, .12]
Winger right	3.45	3.07			
Winger left	2.66	2.74			
Pivot	3.81	2.66			
Defender	2.20	1.99			

Note. CMJ = countermovement jump; HJ = horizontal jump; COD 505 = 10 m shuttle sprint with one change of direction; CI = confidence interval.

Figure 1 Graphical representation of the distribution of interlimb asymmetries in youth male futsal players according to playing position (pivot, defender, left winger, right winger) and physical performance tests (CMJ, HJ, COD). Each zone of the futsal field displays three stacked bars (one per test), with colors indicating the proportion of players presenting asymmetry values <10% (green), 10–15% (yellow), and >15% (red).



Note. CMJ = countermovement jump; HJ = horizontal jump; COD = 10 m shuttle sprint with one change of direction.

In the present study, no significant differences in interlimb asymmetries were found between playing positions in any of the tests performed (CMJ, HJ, and COD 505), indicating that this phenomenon does not appear to be determined by the players' specific roles. These results are consistent with those reported by Spyrou et al. (2024), who also found no significant differences in CMJ variables when comparing positions among futsal players ($p > .05$; effect size between .00 and .51). Conversely, Albalad-Aiguabella, Mainer-Pardos, Roso-Moliner, et al. (2025) observed significant differences in unilateral CMJ between wingers and pivots, with a very large effect size ($p = .03$, effect size > 2.0). Despite the lack of group-level differences, several players in our sample exhibited imbalances greater than 10% in unilateral jumps (CMJ and HJ), reinforcing the need for individualized monitoring. In this regard, previous research has demonstrated that higher interlimb asymmetries can impair physical performance. Fort-Vanmeerhaeghe et al. (2020) found that asymmetries in single leg CMJ were significantly correlated with slower 30 m sprint times ($r = .26$, $p < .05$) and reduced jump performance in the weaker leg (r between $-.26$ and $-.48$, $p < .05$). Similarly, Madruga-Parera et al. (2020) reported in young athletes that single leg CMJ asymmetries were negatively correlated with jump performance (r between $-.32$ and $-.52$), COD (r between $.31$ and $.32$), and repeated-sprint ability (r between $.35$ and $.40$). In contrast, other authors found no significant correlations between jump asymmetry and COD performance (Dos'Santos et al., 2017; Lockie et al., 2014; Loturco et al., 2019). This individualized analysis, together with an understanding of the competitive and technical-tactical demands of each playing position, may provide insights into how asymmetries can influence

position-specific performance. Consequently, training programs should be tailored according to positional demands to prevent asymmetries from negatively affecting key performance variables.

The results of the present study showed a positive and significant correlation between asymmetry in CMJ and HJ performance ($r = .31$; $p < .01$), indicating that players exhibiting greater imbalances in the vertical plane also tend to display them in the horizontal plane. This finding aligns with previous research in team sports, where unilateral strength deficits in the weaker leg have been consistently shown to affect both vertical and HJ performance. No significant correlations were found between jump asymmetries (CMJ and HJ) and COD asymmetries, supporting the notion that COD represents a distinct physical quality, more influenced by technical, coordinative, and neuromuscular control factors (Fort-Vanmeerhaeghe et al., 2020; Villanueva-Guerrero et al., 2025). Since the magnitude of asymmetries varies depending on the test, Bishop et al. (2021) recommend an individualized approach when analyzing and addressing physical imbalances, considering the athlete's personal characteristics and the specific assessments employed.

From a mechanical perspective, the constant repetition of unilateral actions in futsal may induce the development of interlimb asymmetries. Previous studies have shown that repetitive actions predominantly performed with the dominant leg (e.g., passes, kicks, decelerations) lead to asymmetric functional adaptations (Barbieri et al., 2015). Palucci Vieira et al. (2021) analysed 5,856 game actions during the Futsal World Cup. They demonstrated that players used their dominant leg significantly more often ($p < .01$). Similarly, Barbieri et al. (2015) reported that shots with

the dominant leg achieved higher velocity (24.27 ± 2.18 m/s vs. 21.62 ± 2.02 m/s) and accuracy (1.17 ± 0.33 m vs. 1.56 ± 0.49 m) than those performed with the non-dominant leg. These findings suggest that a higher frequency of technical actions executed with one leg may contribute to the development of functional interlimb asymmetries (Hart et al., 2016). These adaptations may increase unilateral load and predispose athletes to a higher injury risk when asymmetries exceed certain thresholds (Ascenzi et al., 2022). Indeed, longitudinal studies have shown that greater asymmetries in single-leg vertical jump performance predict a higher incidence of injuries (Fort-Vanmeerhaeghe et al., 2022). Overall, these findings suggest that, although positional differences may be inconsistent, identifying individual imbalances exceeding 10% is crucial to understanding and anticipating their impact on physical performance and injury incidence (Szabó et al., 2025).

Finally, the analysis of asymmetry distribution revealed that high imbalances ($\geq 10\%$) were more prevalent in the CMJ test than in the HJ or COD tests. Almost all players showed low asymmetry values ($< 10\%$) in HJ and COD, whereas 38.9% of pivots and 40.7% of right wingers exceeded the 10% threshold in CMJ. This trend aligns with previous findings indicating that unilateral vertical jumps tend to produce greater interlimb asymmetries than HJ. From a practical perspective, these results highlight the importance of individualized monitoring of asymmetries in young players. Although no significant group-level differences were found according to playing position, the detection of individuals with $> 10\%$ asymmetry underscores the need for strength and conditioning coaches to identify and implement specific training strategies to correct these cases (Szabó et al., 2025). Unilateral strength training and specific prevention strategies are commonly recommended to reduce asymmetries.

This study presents several limitations. First, the sample consisted exclusively of elite youth futsal players; therefore, the findings cannot be generalized to professional players, other age categories, or female futsal athletes. Another limitation is that the assessments were conducted at a single point in the season. Longitudinal studies would be useful to monitor how asymmetries evolve throughout the competitive year and even across multiple seasons during athletes' maturation. Additionally, the relationship between physical asymmetries and technical-tactical performance in futsal remains to be explored. It would be interesting to examine whether players with greater interlimb imbalances also display differences in match performance, such as turning efficiency or accuracy when using the non-dominant leg. Integrating match-derived metrics could help bridge the gap between laboratory-based asymmetry assessments and the real game context.

Conclusions

In conclusion, this study showed that interlimb asymmetries in elite youth futsal players do not differ significantly according to playing position (right winger, left winger, pivot, or defender). Although mean imbalance magnitudes

generally remained below 10%, individual cases of pronounced asymmetry ($> 10\%$) were observed, particularly in the CMJ. These findings have practical implications for coaches and practitioners. They emphasise the importance of routinely monitoring interlimb asymmetries and individualising training and injury prevention strategies for players who exceed the 10% threshold. It is also advisable to employ multiple unilateral assessments to capture the variability of asymmetry profiles across different physical tasks. Overall, systematic asymmetry monitoring can support better performance management and contribute to reducing injury risk in youth futsal.

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Conflict of interest

The authors report no conflict of interest.

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