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ORIGINAL RESEARCH

Characterization of the lower limb dynamic balance and ankle dorsiflexion in young male futsal players: implications for performance and injury prevention

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Abstract

Dynamic balance and ankle dorsiflexion are associated with performance and injury risk in young athletes. The aim of this study was to characterize lower limb dynamic balance and ankle dorsiflexion in young futsal players and to understand their relationships. Eighteen young male futsal players (with 15.2 ± 1.2 years of age and with a right lower limb dominance) were evaluated for dynamic balance of both lower limbs using the Y-balance test (LQYBT). Ankle dorsiflexion range of motion (DROM) was measured during the weight-bearing lunge test. There were no significant differences in dynamic balance variables between the two sides ($p > 0.05$). However, the composite scores (CS) of both lower limbs showed a risk of injury (CS was less than 89%). Ankle dorsiflexion of the right lower limb was significantly greater than that of the left lower limb (mean difference = 1.00, 95% confidence intervals (CI) = −0.00 to 2.00, $t = 2.11$, $p = 0.050$, $d = 0.50$). Significant correlations and relationships between ankle dorsiflexion and dynamic balance were found only on the right side. The highest correlation ($r_s = 0.598$; $p = 0.009$) and the highest relationship ($R^2 = 0.50$; $p = 0.001$) were observed with the relative anterior reach. The present results indicate that young futsal players have poor dynamic balance scores. Ankle dorsiflexion was only significantly related to dynamic balance on the right side. Further research is needed to better understand these relationships in youth futsal.

Keywords

Balance; Symmetry; Youth; Futsal; Range of motion; Injury

1. Introduction

Futsal is a team sport that is growing in popularity around the world. Its minimal equipment requirements and smaller number of players required per team make it more inclusive and accessible to children of all skill levels and physical abilities [1]. With fewer players on the field, each player has more opportunities to touch the ball, participate in the game, and contribute to their team's success, fostering a sense of inclusion and belonging [1]. One of the main reasons for this is that it is played on a smaller field (*i.e.*, indoor hard court) compared to traditional football. This makes the game faster and more intense. Due to the small playing area (about a quarter the size of a standard football field in terms of area), players must have quick reflexes, excellent ball control, and precise passing skills, resulting in an exciting and dynamic style of play [2]. Consequently, futsal has different demands compared to football, regarding technical and physiological requirements [3]. It has been shown that futsal players have a higher metabolic power and cover more distance in small-sided games compared to football players [4]. Again, due to the small playing area, futsal players must perform all technical drills very quickly with several changes of direction and develop a high capacity for intermittent endurance, repeated sprinting, leg power and agility [5].

Dynamic balance is characterized by the ability to perform a task while maintaining or regaining a stable position [6]. It refers to the ability to maintain stability and control of the body's center of mass while performing dynamic movements [7]. Therefore, the ankles are critical for maintaining stability during such dynamic tasks by providing a stable base of support and for controlling lower limb movements. Weakness or instability in the ankles can lead to decreased dynamic balance, increased risk of falls, and potential injury during physical activities [8]. Given the characteristics and demands of futsal, it can be assumed that balance plays a key role in the sport's technical drills. Overall, studies have shown that dynamic balance has a strong relationship with sprinting and directional change in athletes [9, 10]. That is, athletes with better scores on dynamic balance tests are more likely to perform better on physical tests related to sprinting and change of direction. In addition, dynamic balance testing is also used to identify athletes who are more likely to be injured and to understand how to minimize that risk [11, 12]. Football players have been reported to have good levels of dynamic balance compared to other athletes [13]. However, little is known about the dynamic balance in futsal players. Based on the aforementioned characteristics of futsal (namely, rapid and multiple changes of directions with a high capacity for intermittent endurance), it can be argued that dynamic balance may play a key role in such motor control tasks. On the one hand, it has been shown that senior amateur futsal players performed poorly in dynamic balance tests using the Y-balance test [14], *i.e.*, largely below the cut-off values indicated for this test in terms of injury risk [11]. On the other hand, there is little evidence on this topic in young futsal players [15].

Ankle dorsiflexion (DROM) is another parameter strongly associated with both athlete performance and injury risk [16, 17]. This is especially true in sports that require sprinting, change of direction, and lower limb strength and power [18, 19]. For example, it was found that athletes with poor results in sprinting tests and lower standing long jump scores were those with a higher risk of injury based on the ankle dorsiflexion [17]. In the specific case of futsal, ankle dorsiflexion has been shown to have a strong relationship with athletes' dynamic balance, with higher scores in the former being associated with better scores in the latter [20]. However, as mentioned above, there is little evidence on these topics in young futsal players. Although information on dynamic balance can be found [15], to our knowledge there are no reports on ankle dorsiflexion and its relationship to dynamic balance in youth futsal. Findings related to these topics could help promote specific training designs to overcome hypothetical limitations related to these variables. Indeed, futsal (as well as football [21]) has been reported to be a sport with a high prevalence and incidence of lower limb injuries, at least in adult players [22]. Specifically, the ankle and knee were found to be the anatomical regions where injuries were significantly more frequent and recurrent [22, 23].

Therefore, the objectives of this study were to characterize the lower limb dynamic balance and DROM in young futsal players and to understand their relationships. It was hypothesized that young futsal players would have a symmetrical profile in the dynamic balance with a low risk of injury. There would also be non-significant differences in the DROM between sides, and a strong relationship between the dynamic balance and DROM would be found.

2. Materials and methods

2.1 Participants

Sample size calculation was performed using G*Power (v.3.1.9.7, University of Düsseldorf, Düsseldorf, Germany) based on the relationship between weight-bearing lunge test (WBLG) and Y-balance anterior reach. Eleven to 37 participants were required to detect a moderate to strong effect size ($0.40 \leq r < 0.70$) with 80% power ($\alpha = 0.05$, one-tailed test) for a "correlation: bivariate normal model" statistical test. The sample consisted of 18 young male futsal players (15.2 ± 1.2 years; 62.4 ± 11.7 kg of body mass; 173.1 ± 6.1 cm of height; 0.92 ± 1.06 years of maturity offset), including five defenders, six wingers, four pivot players, and three universal players. The players regularly participated in regional championships and were considered Tier 2 athletes [24]. They were recruited from a regional team of the most talented players in their age-group competing at the regional level. At the time of data collection, they were preparing to compete at the national level competition. Data collection took place four months after the start of the regional season. Prior to data collection, the players had two 90-minute training sessions per week. To be included in the evaluation sessions, players had to be completely pain free at the time of the study and had to have no chronic injuries since the beginning of the season. They were excluded from the evaluation sessions if they were receiving medical treatment at the time or if they reported pain during the Y-balance test, as reported by others [25]. All players were fit and uninjured. Foot dominance was assessed by self-report [26]. All players were right-sided (*i.e.*, dominant limb—right; non-dominant limb—left).

2.2 Lower-quarter Y-balance test (LQYBT)

Lower limb dynamic balance was measured using the Y-balance test for the lower quarter extremities (LQYBT). This test is a dynamic balance assessment tool that evaluates an individual's ability to maintain stability and control during multi-planar movements. It is commonly used in rehabilitation, sports medicine, and athletic performance settings to assess lower extremity function and identify asymmetries or deficits that may increase the risk of injury [11, 12]. Players were familiarized with the protocol prior to data collection. An expert evaluator explained it and allowed the players to practice it. This was done to ensure a valid reproducibility. All participants followed a protocol that involved supporting one foot on a central stance platform and reaching with the other foot in the anterior, posterolateral, and posteromedial directions (Fig. 1). The test was performed barefoot with both lower limbs and repeated three times with each lower limb [12]. Players were instructed to reach as far as possible while maintaining their balance. The anterior, posteromedial, and posterolateral directions were performed sequentially. Players were instructed to restart the trial if they failed on any of the three trials (anterior, posterolateral and posteromedial). To successfully complete a trial, participants had to perform all three reaches consecutively without touching the ground with the foot. The sum of the three normalized reach distances was then averaged and multiplied by 100 to generate a composite score (CS, in %). The absolute (in cm) and relative (in %) reach differences between the lower limbs were calculated to assess reach symmetry [12]. For these calculations, the lower limb length was measured using a flexible anthropometric tape (RossCraft, Canada) [12]. For qualitative analysis, it has been reported that CS less than 89% and symmetries greater than 4 cm are more likely to result in injury [11].

2.3 Weight-bearing lunge test (WBLT)

Ankle dorsiflexion was measured using the WBLT. Participants performed the WBLT on both limbs. For measurement,

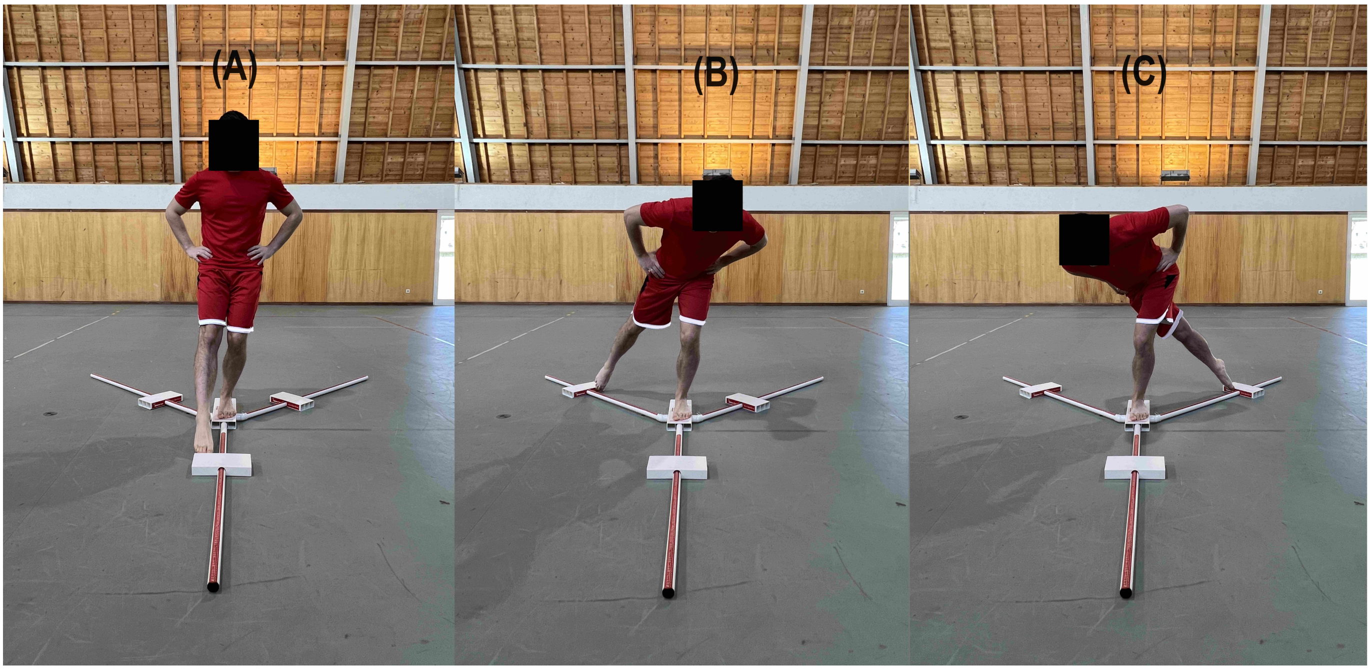

FIGURE 1. Protocol of the lower quarter Y-balance test (LQYBT). Panel (A)—anterior reach; Panel (B)—posteromedial reach; Panel (C)—posterolateral reach.

players were instructed to dorsiflex as far as possible without any assistance or encouragement. They lunged forward and attempted to touch an imaginary vertical line while maintaining heel contact with the ground [27]. The opposite limb was positioned comfortably behind the test limb with hands on hips for stability. No restrictions were placed on the contralateral limb to allow for maximum DROM from the testing limb. To measure the DROM (in degrees), the players' fibular head and lateral malleolus of both limbs were previously marked on with a black pen. The tibial angle of inclination was defined as the angle between a vertical line starting at the lateral malleolus and a second line connecting the lateral malleolus and the fibular head, as proposed by others (Fig. 2) [28]. Players were recorded performing the WBLT in both sagittal planes with a GoPro camera (Hero 7, GoPro Inc., San Mateo, CA, USA) mounted on a tripod 25 cm off the ground and 60 cm away from where they performed the WBLT. The videos were then analyzed using a freely available software package (Kinovea® version 0.9.5). This software has been shown to reliably measure variables related to angular kinematics [29, 30]. Two experts conducted the analyses. They reviewed the videos frame by frame to determine the maximum angle of inclination achieved by the players. The tibial angle of inclination was then measured and used as the DROM. The intraclass correlation coefficient (ICC) between the evaluators showed a very high agreement (ICC = 0.967, $p < 0.001$).

2.4 Statistical analysis

Data distribution and homogeneity were tested using the Shapiro-Wilk and Levene tests, respectively. The data were normally distributed and homogeneity was not violated. Descriptive statistics included the mean, standard deviation and the coefficient of variation (CV, in %). One-way ANOVA (*i.e.*, between-subjects factor) was used to analyze the differences between players based on their position on the field (*i.e.*, defenders, wingers, pivots and universals). The eta-squared (η^2) was used as an effect size index: (i) no effect if $0 < \eta^2 < 0.04$; (ii) minimal if $0.04 < \eta^2 < 0.25$; (iii) moderate if $0.25 < \eta^2 < 0.64$, and; (iv) strong if $\eta^2 > 0.64$ [31]. Whenever appropriate, paired *t*-tests were used to test differences between sides (*i.e.*, right versus left). The significance level was set at $\alpha = 0.05$. Cohen's d was used to estimate standardized effect sizes and interpreted as: (i) trivial, if $0 \leq d < 0.20$; (ii) small, if $0.20 \leq d < 0.60$; (iii) moderate, if $0.60 \leq d < 1.20$; (iv) large, if $1.20 \leq d < 2.00$; (v) very large, if $2.00 \leq d < 4.00$; (vi) nearly distinct, if $d \geq 4.00$ [32]. Spearman correlation coefficient (r_s) with 95% confidence intervals (95% CI) was used to test the correlation between DROMs and CSs in both limbs, as well as DROMs with the LQYBT scores. This was done to assess the strength and direction of the correlations between the variables. Qualitatively, the correlations were interpreted as: (i) negligible if $0 < r_s \leq 0.10$; (ii) weak if $0.10 < r_s \leq 0.39$; (iii) moderate if $0.40 \leq r_s \leq 0.69$; (iv) strong if $0.70 \leq r_s \leq 0.89$, and; (v) very strong if $0.90 \leq r_s \leq 1.00$ [33]. The coefficient of determination (R^2) by simple linear regression was used to explain the variance of the correlations whenever appropriate. This was done to determine the strength of the relationship between variables and to assess the predictive power of the model. The qualitative interpretation was made as: (i) very weak if $R^2 < 0.04$; weak if $0.04 \leq R^2 < 0.16$; (iii) moderate if $0.16 \leq R^2 < 0.49$; (iv) high if $0.49 \leq R^2 < 0.81$, and; very high if $0.81 \leq R^2 < 1.0$ [34].

3. Results

Descriptive statistics are presented in Table 1. The one-way ANOVA showed a non-significant effect of field position on

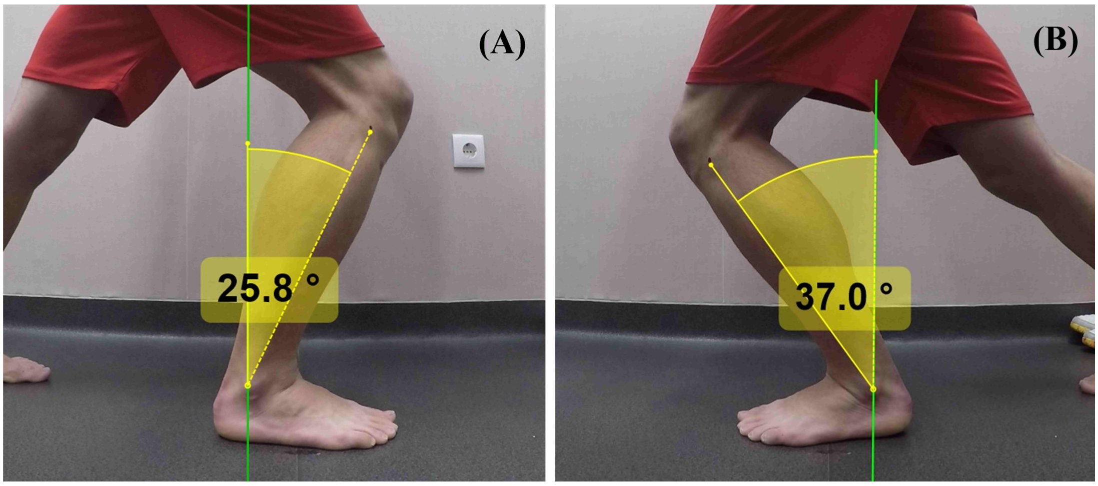

FIGURE 2. Representation of the dorsiflexion range of motion of the ankles. Panel (A)—right limb; Panel (B)—left limb.

TABLE 1. Descriptive statistics (mean ± standard deviation—SD) and coefficient of variation (CV, in %) of the measured variables. Also shown is the one-way ANOVA that tested for differences between positions in the field.

	Mean ± SD	CV	F-ratio (p-value)	η^2
$DROM_{right}$ (°)	39.35 ± 3.82*	9.44	1.233 (0.335)	0.21
$DROM_{left}$ (°)	38.35 ± 3.86*	9.79	1.349 (0.299)	0.22
CS_{right} (%)	87.24 ± 5.26	5.86	0.989 (0.426)	0.18
CS_{left} (%)	88.29 ± 4.92	5.41	1.127 (0.372)	0.19
Anterior differences				
Absolute (cm)	2.89 ± 1.95	65.45	3.341 (0.050)	0.42
Relative (%)	3.40 ± 3.13	89.46	0.361 (0.782)	0.07
Posterolateral differences				
Absolute (cm)	3.84 ± 2.91	73.61	0.976 (0.432)	0.17
Relative (%)	3.82 ± 3.18	81.05	0.668 (0.586)	0.13
Posteromedial differences				
Absolute (cm)	4.84 ± 4.27	85.69	0.270 (0.846)	0.06
Relative (%)	4.88 ± 3.88	77.21	0.279 (0.840)	0.06
Anterior reaches				
$Absolute_{right}$ (cm)	56.06 ± 6.00	10.4	0.044 (0.987)	0.01
$Relative_{right}$ (%)	61.63 ± 5.28	8.32	0.336 (0.799)	0.07
$Absolute_{left}$ (cm)	57.44 ± 5.95	10.07	0.434 (0.732)	0.09
$Relative_{left}$ (%)	63.18 ± 5.63	8.66	0.169 (0.916)	0.04
Posterolateral reaches				
$Absolute_{right}$ (cm)	91.83 ± 6.68	7.07	1.180 (0.353)	0.20
$Relative_{right}$ (%)	101.14 ± 7.12	6.84	1.496 (0.259)	0.24
$Absolute_{left}$ (cm)	92.53 ± 4.35	4.57	1.356 (0.297)	0.23
$Relative_{left}$ (%)	101.97 ± 5.69	5.43	1.970 (0.165)	0.30
Posteromedial reaches				
$Absolute_{right}$ (cm)	89.87 ± 6.97	7.54	0.129 (0.941)	0.03
$Relative_{right}$ (%)	98.94 ± 7.52	7.38	0.991 (0.425)	0.18
$Absolute_{left}$ (cm)	90.78 ± 6.93	7.42	0.563 (0.648)	0.11
$Relative_{left}$ (%)	99.71 ± 7.17	6.98	1.617 (0.230)	0.26

*Lower scripts: right: refers to the right limb; left: refers to the left limb; DROM: dorsiflexion range of motion; CS: lower quarter composite score. *: significant differences between variables ($p \leq 0.05$).*

all variables. This indicates that players from different field positions were similar with respect to these variables. The DROM of the right limb was significantly greater than that of the left limb (mean difference = 1.00, 95% CI = −0.00 to 2.00, $t = 2.11$, $p = 0.050$, $d = 0.50$). Regarding the remaining variables, there were no significant differences ($p > 0.05$) between the sides in CS, anterior, posterolateral, and posteromedial reaches. However, there was a clear tendency for the left limb to have better scores than the right one. The qualitative assessment of the LQYBT revealed that these players were prone to injury as the CS scores were less than 89%. This was also observed in the posteromedial reaches, where the differences between the limbs were greater than 4 cm.

Table 2 shows the Spearman's correlation coefficients between the DROMs (right versus left), CSs (right versus left), and between the corresponding DROM and CS (right and left). The DROMs ($r_s = 0.845$, $p < 0.001$) and CSs ($r_s = 0.712$, $p < 0.001$) showed strong and significant correlations (Table 2). Significant correlations between DROMs and variables related to LQYBT were found only on the right side. DROM_{right} showed a moderate and significant correlation with CS_{right} ($r_s = 0.540$, $p = 0.021$). DROM_{right} was also significantly correlated with the relative anterior and posteromedial reaches (Table 2).

Simple linear regressions between the variables that presented significant correlations are shown in Fig. 3. The DROM (panel A: $R^2 = 0.74$, $p < 0.001$) and CS (panel B: $R^2 = 0.52$, $p < 0.001$) showed a high relationship between sides. This indicates that players with a larger DROM on the right side are more likely to have a larger DROM on the left side. The same trend was found for CS. Moderate to high relationships were observed between DROM_{right} and the LQYBT parameters, with the greatest relationship being observed with the relative anterior reach ($R^2 = 0.50$, $p = 0.001$).

4. Discussion

The aim of this study was to characterize lower limb dynamic balance and DROM in young futsal players and to understand their relationships. The main findings indicated that young futsal players had overall poor LQYBT (dynamic balance) scores. Specifically, their CS scores (both lower limbs below 89%) and posteromedial differences between the limbs (greater than 4 cm) indicated a risk of injury. Significant differences, but with small effect sizes, were observed between sides in the DROM. Significant and high relationships were found between CS (right versus left) and DROM (right versus left). This indicates that players who had better CS scores and greater DROM in the right limb were more likely to have better CS scores and greater DROM in the left limb. Significant relationships between LQYBT parameters and DROM and were found only in the right side.

Studies of dynamic balance using the LQYBT have increased over the years. This is due to the important results that can be obtained. These allow to characterize the dynamic balance of the athletes and also to compare the sides in order to identify imbalances [25, 35, 36]. The present results showed that young futsal players presented CSs (both right and left) very close but still lower than the 89% and posteromedial differences greater than 4 cm, suggesting a risk of injury [11]. As mentioned above, no information could be found on dynamic balance performance measured with the LQYBT in young futsal players. However, Rossler and co-workers [37] showed that young male football players had CS scores well above the 89% cut-off in both limbs. The authors analyzed the effects of a "FIFA 11+" (Fédération Internationale de Football Association) intervention program focused on motor performance [37]. This program has previously been shown to promote significant improvements in strength, balance, sprint and power in young male futsal players [15].

In both football [37] and futsal [15], training interventions focused on motor performance have been shown to improve players' balance. In the case of football, this intervention program ("FIFA 11+") promoted an increase (better scores) in LQYBT CS, but not significantly [37]. In futsal, where balance was measured using the single-legged flamingo balance test (*i.e.*, static balance), players significantly improved their static balance mostly on the non-dominant limb [15]. On the other hand, a study of senior futsal players showed similar results to the present findings, *i.e.*, CS scores below the 89% cut-off [14]. The same program "FIFA 11+" was used to test differences against a control group. At baseline, both groups had CS scores close to 80% in both limbs. The authors acknowledge that even a 10-week dedicated balance (static and dynamic) and proprioception intervention program did not promote meaningful gains in such outcomes [14]. It can be argued that: (i) such adult players may have acquired or consolidated their motor skills "incorrectly" during their learning/training processes leading to these "no-return" balance deficits; and (ii) the specificity of the sport itself could lead to such deficits. Therefore, coaches and practitioners of young futsal players should be advised to monitor their players' balance and other parameters related to risk of injury in the lower limbs (such as the ankle dorsiflexion) longitudinally. This will help to understand how and if the practice of futsal leads to a decrease in the players' dynamic balance, which may promote negative effects on performance.

Regarding the DROM results, it has been argued that there is a lack of information on ankle motion in futsal players [36], especially as this is a population highly susceptible to ankle disorders. The current results showed DROMs of 39.35 ± 3.82º and 38.35 ± 3.86º for the right and left limbs, respectively. These values are qualitatively considered normal for this age-group [38], and it should be noted that the current protocol did not have any restriction regarding the contralateral limb. A study by Robles-Palazón and co-workers measured the DROM in young futsal players from different age-groups based on their maturation status (*i.e.*, U12, U14, U16 and U19) [39]. Comparing the present results with those of this study (for a similar age), our players presented a slightly higher DROM (Robles-Palazón and co-workers study: DROM = 36.6 ± 5.3º, considered a normal qualitative result). However, it was noted that when the age-groups were divided by maturation (not by age), there was a tendency for DROM to decrease with increasing maturation (but without significant differences and with the contralateral knee flexed—reducing DROM restriction). That is, mature players tended to have lower values of DROM compared to their younger counterparts. This seems to be

TABLE 2. Spearman's correlation coefficients (r_s) with 95% confidence intervals (95% CI) between the measured variables. Only significant correlations ($p < 0.05$) are shown.

	$DROM_{right}$	CS_{right}
$DROM_{left}$	$r_s = 0.845$; $p < 0.001$ (95% CI: 0.616 to 0.943)	
CS_{right}	$r_s = 0.540$; $p = 0.021$ (95% CI: 0.083 to 0.809)	
CS_{left}		$r_s = 0.712$; $p < 0.001$ (95% CI: 0.355 to 0.888)
Anterior reach		
$Relative_{right}$	$r_s = 0.598$; $p = 0.009$ (95% CI: 0.167 to 0.837)	
Posteromedial reach		
$Relative_{right}$	$r_s = 0.529$; $p = 0.024$ (95% CI: 0.068 to 0.804)	

Lower scripts: right: refers to the right limb; left: refers to the left limb; DROM: dorsiflexion range of motion; CS: lower quarter composite score.

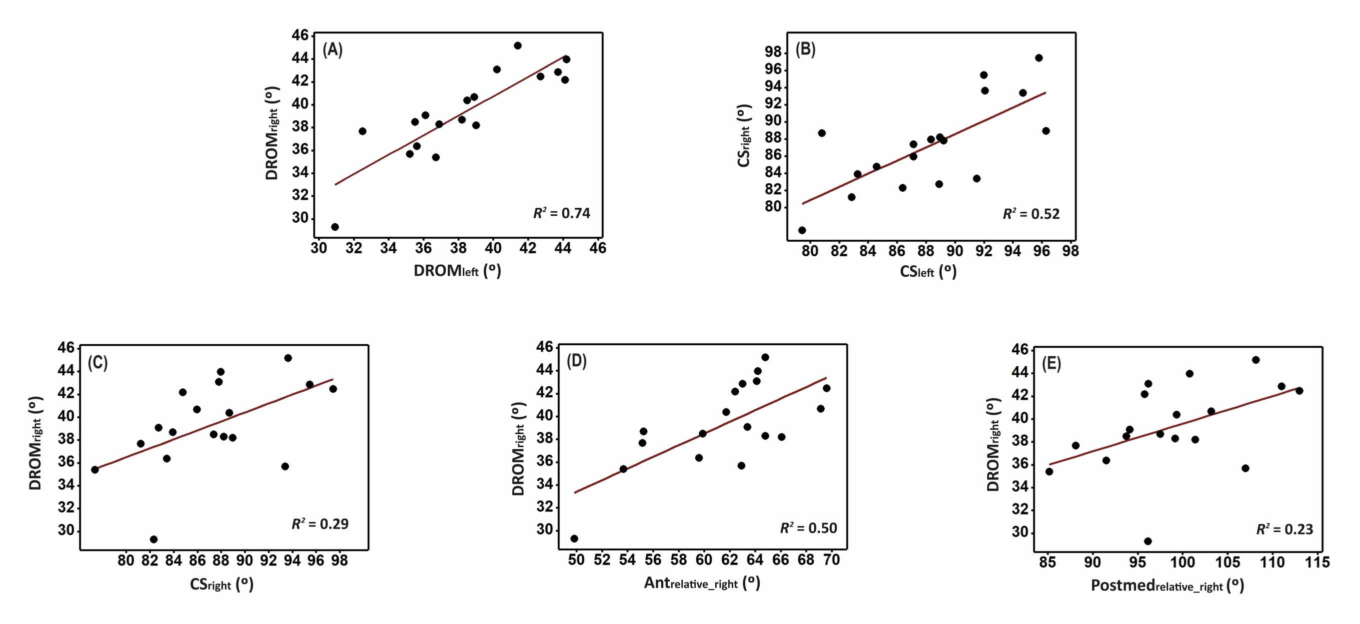

FIGURE 3. Simple linear regression between variables that showed significant correlations. (A) relationship between DROM's. (B) relationship between CS's. (C) relationship between DROM and CS of the right side. (D) relationship between DROM and $Ant_{relative}$ of the LQYBT of the right side. (E) relationship between DROM and $Postmed_{relative}$ of the LQYBT of the right side. Lower scripts: right: refers to the right limb; left: refers to the left limb; DROM: dorsiflexion range of motion; CS: lower quarter composite score; LQYBT: lower-quarter Y-balance test; $Ant_{relative}$: anterior relative reach; $Postmed_{relative}$: posteromedial relative reach.

consistent with other studies that have measured adult players. Adult players presented lower values of DROM (also with the contralateral knee flexed) compared with the present sample with values of 35.8 ± 5.6° (dominant) and 36.0 ± 5.8° (non-dominant) [40]; and 36.63 ± 5.08° (dominant) and 35.77 ± 5.41° (non-dominant) [36]. Therefore, it can be suggested that DROM decreases with age in futsal players, and this decrease may also be related to the specific motor tasks of futsal. In addition, mixed results were found regarding the values of DROM presented by each limb. There are cases where the dominant limb presented greater DROM and *vice versa*. This suggests that further research is needed to better understand the effects of futsal training on DROM.

Regarding the relationship between DROM and LQYBT (where DROM is measured with the WBLT), only positive correlations (r_s) and relationships (R^2) between DROM and LQYBT in the CS, relative anterior reach, and relative posteromedial reach in the right side (dominant) were found. That is, players with greater DROM on the right side were more likely to have greater CS scores and achieve greater anterior and posteromedial distances. It has been suggested that the DROM has a positive and strong relationship with the LQYBT [35]. This is particularly true for the anterior reach, as participants are instructed to move the tibia forward in both tests [35]. In fact, the dynamic balance performed with the LQYBT is often used as a measure of dynamic balance and proprioception, which are influenced by several factors, including ankle stability [41]. Therefore, investigating such a relationship may provide an explanation for how DROM helps futsal players maintain their dynamic balance. Previous studies have shown that there is a significant and positive relationship between the DROM and the anterior reach in the LQYBT [36, 42]. One study analyzed this relationship in futsal, but in elite players [36]. However, in contrast to the current results, the authors found that the greatest correlations and relationships were observed in the non-dominant limb. In fact, the literature has shown that the non-dominant lower limb is more likely to have better balance and DROM [43, 44]. This is because when one limb is weaker or less dominant, the body often compensates by improving the strength, coordination, and proprioception in the opposite limb. Thus, such compensation may lead to better balance in the non-dominant limb [45]. On the other hand, a systematic review with meta-analysis on the role of dominance in balance found that lower limb dominance did not influence balance performance, at least in unilateral stance [46]. Therefore, it can be argued that more information is needed to understand the relationship between DROM and dynamic balance performed with the LQYBT in different age-groups.

Despite the poor CS in both limbs, non-significant differences were found between CSs and reaches in all three directions, and a high and positive relationship was found between CSs. This indicates that the players presented similar results on both sides, *i.e.*, symmetry, and players with better scores on the right side were more likely to present better scores on the left side. A systematic review has shown the importance of measuring lower limb asymmetries, indicating that they are detrimental to performance [47]. In the case of dynamic balance as measured by the LQYBT, studies have shown that adult/elite futsal players tend to have non-significant differences between CSs indicating similar overall dynamic balance scores for both lower limbs [14, 36]. To our knowledge, there is no information on this topic (LQYBT) in young futsal players. However, young football players also showed non-significant differences between CSs [25, 37]. Therefore, it can be stated that despite the CS scores, players tend to have similar scores of dynamic balance in both lower limbs evaluated with the LQYBT.

Regarding DROM, the current data showed significant differences between sides (right limb greater than the left), but with a high correlation. That is, players with greater DROM on the right side were more likely to have greater DROM on the left side. Nevertheless, an asymmetric profile can be considered in this case. This has also been demonstrated by others in healthy male adults [44]. However, no information on this subject could be found among young futsal players. However, it has been reported that adult/elite futsal players tend to have non-significant differences between the lower limbs [36, 40]. In young football players, a study also found non-significant differences between the two sides in several age-groups [39]. Therefore, it seems that the measurement of DROM and its effects on the performance of athletes should be investigated. As mentioned above, it has been suggested that there is a high prevalence of asymmetry in several sports where the lower limbs are heavily recruited. Furthermore, such differences may have a significant impact on performance [47]. On the other hand, it has been argued that such asymmetries may not be strongly supported by scientific evidence, and the nature of the asymmetry is often not defined [48].

It should be emphasized that these results are based on young futsal players who regularly compete at regional level and occasionally at national level. Consequently, it is not possible to state that the implications of the present findings could be applied to other age-groups or levels of competition. The main limitations are that: (i) dynamic balance measured by force plates or by computerized dynamic posturography could add more insight to the present findings, and; (ii) the DROM based on the WBLT was measured without restriction of the contralateral knee. That is, the players performed the WBLT in a way that allowed them to achieve the maximum range of motion of the performing limb. Regarding the former, the proposed techniques could be more accurate and therefore provide more sensitive results about the players' dynamic balance. Nevertheless, as mentioned above, the LQYBT is considered to be a feasible and reliable alternative to such complex techniques. With regard to the latter, it was decided not to restrict the contralateral (extended) limb, since the main objective of the LQYBT is to achieve the greatest range of motion. This also requires the participants to focus on the ankle by promoting the greatest DROM.

Future studies should focus on understanding (i) these relationships in different age-groups and by position on the field, and; (ii) whether futsal practice has a negative effect on both the LQYBT and DROM (regarding DROM, in both situations: with the contralateral knee extended and flexed). In addition, longitudinal studies should be conducted to understand how the LQYBT and DROM change with futsal practice. This could also provide deeper insights into the relationship between LQYBT and DROM in which the ankle plays a key role. Besides these relationships, coaches and practitioners can also monitor other parameters related to the players' balance and risk of injury in the lower limbs to better understand how injuries can be minimized.

5. Conclusions

The young futsal players included in this study had poor dynamic balance scores as measured by the LQYBT (*i.e.*, risk of injury). As futsal is strongly related to balance, coaches and practitioners should be advised to monitor their players and design and implement specific training programs to overcome this limitation. Significant correlations and relationships between LQYBT and DROM parameters were found only for the right side. This suggests that players with better dynamic balance and greater reaches of the right limb are more likely to have greater DROM on the same side. No significant differences were found between the limbs for LQYBT. Conversely, significant differences were found for DROM. These findings suggest that further research is needed in young futsal players to better understand these relationships.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed in the current study are available from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

JEM, VPL and TMB—designed the research study; provided assistance and advice on data collection. TS and JPO—performed the research. JEM—analyzed the data; wrote the manuscript. All authors contributed to the editorial changes in the manuscript. All authors read and approved the final version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All participants in this study and their parents were informed about the experimental procedures. Informed consents were obtained by the players' parents or legal guardians. Protocols and informed consent forms were approved by the Ethics Board of the Polytechnic Institute of Bragança (No. 127/2023). All study procedures were performed in compliance with the Declaration of Helsinki.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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