

1 **Difference in Change of Direction Performance between College Basketball Players with High and**

2 **Low Change of Direction Deficit, Shuffle, and Jump Asymmetry**

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Abstract

This study aimed to (1) assess inter-limb asymmetry in shuffle, change of direction deficit (CODD), single-leg jump performance among college basketball players, and (2) compare change of direction speed between high and low asymmetry groups. Thirty-six players (16 males, 20 females) completed single-leg countermovement jump, lateral jump, CODD, and 5-m shuffle tests. Asymmetry was calculated using: $(\text{dominant} - \text{non-dominant}) / \text{dominant} \times 100\%$. The participants were median-split into high-asymmetry ($n = 18$) and low-asymmetry ($n = 18$) groups based on the calculated asymmetry scores. Change of direction performance was evaluated using the T-test, Lane test, and Run-Shuffle-Run (RSR) test. The inter-limb asymmetry score ranged from 2.77%–15.16%. Grouping based on CODD asymmetry showed a significant difference in RSR performance ($p < 0.05$, $ES = 0.74$), while grouping based on shuffle asymmetry also revealed a significant difference in T-test performance ($p < 0.05$, $ES = 0.72$), indicating that inter-limb asymmetry of the CODD and shuffle have a significant negative impact on change of direction speed. Coaches should consider asymmetries in CODD and shuffle during movement assessments, as higher asymmetry significantly impairs performance in RSR and T-test.

Key Words: Interlimb, Physical Tests, Movement Performance

Introduction

Basketball is a high-intensity intermittent sport that involves a significant amount of unilateral jumping and multi-directional movements during both competition and training[1]. These demands necessitate balanced development of both limbs and a reduction in inter-limb asymmetry in basketball players[2]. Inter-limb asymmetry typically refers to differences in performance or function between limbs[3]. Studies have shown that inter-limb asymmetry is correlated with different performance[2,4]. For example, Bishop et al. found that asymmetry in single leg drop jump height was significantly associated with performance in the 505 agility test ($r = 0.65$, $p < 0.01$), and asymmetry in single leg countermovement jump (SLCMJ) height was correlated with jumping ($r = 0.47\text{--}0.57$, $p < 0.05$) and sprinting ($r = 0.49\text{--}0.59$, $p < 0.05$) performance[4,5]. Madruga et al. discovered that asymmetry in single leg lateral jump (SLLJ) was significantly associated with 180-degree change of direction (COD) ability ($r = 0.39$, $p < 0.05$)[6]. Moreover, Ding et al. found that asymmetry in ankle strength was significantly correlated with vertical jump performance among youth basketball players[2]. Arboix-Alió et al. found that greater asymmetry in elite female basketball players was significantly associated with slower COD performance (p range = -0.67 to 0.57)[7]; Sugiyama et al. reported a significant positive correlation between the asymmetry index of ankle joint kinematics and the asymmetry index of jump height in male collegiate basketball players (r range = 0.41 to 0.52)[8]. Thus, it is suggested that reducing asymmetries may be beneficial for athletic performance and functional outcomes[3,9].

COD performance is critical for success in team sports[10,11]. Although basketball is often regarded as a sport dominated by vertical jumping, research has shown that the frequency of directional changes and velocity adjustments during a game matches or even exceeds the maximum number of vertical jumps performed[1,12,13]. For instance, Taylor et al. reported that lateral movements occur up to 450 times per game, accounting for approximately 18.1% to 42.1% of total game time, highlighting the importance of lateral movement in basketball[13]. Furthermore, lateral movement is often combined with various sprints, decelerations, direction changes, and side cuts, which collectively contribute to COD performance in basketball players[14]. Therefore, when evaluating COD in basketball athletes, it is essential to consider whether the tests used reflect the sport-specific demands. Tests such as the T-test, Lane-Test, and Run-Shuffle-Run (RSR) test have been validated as suitable COD assessments for basketball players[15].

Previous studies have suggested the use of the change of direction deficit (CODD) to assess COD ability, calculated as the difference between the 505 test time and the 10-m sprint time[16,17]. A key advantage of

this measure is that it provides a more comprehensive evaluation of COD ability and has been demonstrated to be a sensitive indicator of interlimb asymmetry in athlete populations[18]. Previous studies have validated the importance and reliability of CODD for basketball players. For example, Gonzalo-Skok and Bishop compared the differences in CODD between single and multiple COD tasks among basketball players of different ages, indicating that CODD is a more independent COD indicator, and that integrating CODD into COD tests at different angles is also reliable[19,20]. Scanlan et al. examined the effectiveness of CODD in detecting the decline in COD speed during repeated sprints, recommending the use of the CODD method in basketball-specific tests to more accurately assess fatigue-related changes in COD ability[21]. The study also indicated that CODD has higher sensitivity in detecting asymmetry, compared to total time[17]. Additionally, previous research has identified significant asymmetry in lateral shuffle performance among basketball players[29]. Although previous studies have indicated that inter-limb asymmetry is associated with jumping, sprinting, and general COD performance, most of this research has focused on general athletic performance measures and lacks in-depth exploration of the relationship between asymmetry and basketball-specific COD performances (e.g., T-test, Lane-test, and Run-Shuffle-Run test). Furthermore, while the CODD has been shown to be a sensitive indicator for assessing COD ability and asymmetry, its association with actual COD speed has not been systematically validated in the context of basketball[22,23]. Similarly, although lateral shuffle is a frequently performed movement in basketball, there is limited empirical evidence on whether asymmetry in this movement affects COD performance. Considering that CODD is currently the most effective test for evaluating COD ability and that shuffle is a crucial movement skill in basketball, it is necessary to employ asymmetry assessment methods that best align with the demands of basketball and examine their relationship with COD speed.

Therefore, the aim of this study is to 1) evaluate the shuffle, COD and jump performance, and calculate the asymmetry score in shuffle, CODD, and single leg jump performance among collegiate basketball players and 2) examine the relationships between these asymmetries and COD performance, and examine the difference in COD performance between high and low asymmetry group basketball players. Our hypothesis is that players with high CODD and shuffle asymmetry would demonstrate significantly lower COD performance compared to those with low asymmetry.

Methods

Study Design

This study employed a cross-sectional design to evaluate the relationship between shuffle, 10-m sprint, single leg jump (SLCMJ, SLLJ,) and COD asymmetry (505 and CODD) and CODS performance (T, Lane and RSR test). The formal testing was conducted in an indoor basketball court. Participants attended the court twice, spaced 72h apart. Before the start of first testing session, they completed a standardized warm-up, which included jogging and dynamic stretching, followed by two familiarization trials for the single leg jump and shuffle tests. After a two-minute rest period, the formal single-leg jump test was conducted, followed by the shuffle test and then the 505 test along with a 10-meter sprint test. All participants were asked to indicate their lateral preference for kicking a ball. The dominant limb (DL) was defined as the preferred kicking leg, while the supporting leg was identified as the non-dominant limb (NDL). During the second visit, participants performed the same standardized warm-up, followed by a familiarization session for the T-test, Lane test, and RSR test. After a five-minute rest period, the formal testing for the three CODS assessments was conducted. All tests were performed three times, with the best result used for the final analysis. The SLCMJ was measured using a phone app (MYJUMP2), which calculates flight time and jump height from 240 fps video, with the high validity and reliability ($ICC > 0.95$)[24,25]. The 505, shuffle and 10-m sprint were measured using another phone app (CODtimer)[26], which relies on high-frame-rate video recordings in 240 fps to detect key movement frames, shown excellent agreement and strong test-retest reliability ($r = 0.99$)[27]. All tests were conducted between 2:30 PM and 5:00 PM, aligning with the regular training schedule of the university basketball team.

Participants

A total of 36 basketball players (16 male and 20 female athletes; age: 20.22 ± 1.1 years; body mass: 74.44 ± 14.21 kg; body height: 184.81 ± 12.62 cm; mean $\pm$ SD) participated in this study. All athletes were members of a university basketball team, training at least four times per week for basketball and twice per week for strength training, with a minimum of five years of basketball training experience. Participants had no history of major injuries in the six months prior to the study and no chronic diseases affecting their health. Before participation, all subjects provided written informed consent and were familiarized with the entire experimental procedure. The study was approved by the research ethics committee (Approval Number: 2024409H).

Measures

5-m Shuffle

Participants performed six repetitions of a 5-m lateral shuffle. Each participant started behind the starting line in a defensive shuffle stance with knees slightly bent. Upon hearing the researcher's command, they shuffled as quickly as possible in the direction of the testing leg for 5 meters. Timing stopped when the participant's body crossed the marker post at the finish line. Each leg was tested three times, with a 60-second rest interval between trials. An iPhone was placed 5 meters directly in front of the finish line to ensure the entire shuffle movement was captured. The key frames used for calculating shuffle performance included: (1) the first frame in which the athlete's foot left the ground (start of the shuffle) and (2) the frame in which the athlete's foot crossed the marker post (end of the shuffle)[26].

505 Change of Direction Speed

Each participant completed six trials of the test, with three trials performed for each leg. At the start of the test, participants stood behind the starting line in a two-point stance and were instructed to complete each trial "as fast as possible." To ensure full recovery, a 3-minute passive rest period was provided between trials[18]. A researcher experienced in using CODtimer recorded the trials using an iPhone 13 Pro, which was mounted on a tripod positioned 5 meters away from the track, perpendicular to the running direction. The tripod height was individually adjusted for each participant to match the height from the ground to their greater trochanter. To assist with video analysis, a vertical marker post was placed at the timing point. The initial and final frames were determined by the moment when the participant's hip joint center aligned with the vertical marker post[28].

Single Leg Countermovement Jump

Participants stood on one leg with their hands placed on their hips and were instructed to squat to a self-selected depth, then jump as high as possible using the support leg. During the jump, the non-support leg remained slightly bent at the knee, with the foot positioned near the ankle of the support leg. Excessive swinging of the non-support leg was not allowed. Each leg completed three trials of the SLCMJ, with a 60-second rest interval between each trial. Any trial that did not meet the movement standards was considered invalid. The first frame of takeoff and landing was used for calculation. The highest jump height for each leg was recorded for data analysis[29].

Single Leg Lateral Jump

A measuring tape was placed on the floor to measure the length of the SLLJ. Participants started from the 0 cm mark, performing a single-leg jump after first bending their knee and squatting to a self-selected depth, then jumping as far as possible laterally. When jumping from the left leg, participants were instructed to keep both hands on their hips and jump as far to the right as possible. Upon landing, participants were required to land with both legs to enhance stability and hold the landing position for 2 seconds. The distance between the outer edge of the landing foot (the part closest to the 0 cm mark) and the takeoff point was then measured. Each leg completed three jump trials, with a 60-second rest interval between each trial, and the longest jump from each leg was selected for data analysis[6,29].

T-test

The T-test was conducted on a basketball court. The first cone was placed 10 meters from the starting line, with two additional cones positioned 5 meters to each side. Participants started from the starting line in a standing position and sprinted to the first cone at 10 meters, touching the top of the cone with their left hand. Then, they performed a left lateral shuffle for 5 meters to the second cone and touched the top of the cone again with their left hand. Next, they shuffled 10 meters to the third cone and touched the top with their right hand. Afterward, they shuffled left back to the first cone and finished with a backward run to the starting line[15]. Each participant completed three trials, attempting to finish the test as quickly as possible, with a 3-minute rest interval between each test[18]. The experimenter fixed an iPhone on a tripod 5 meters vertically and 5 meters horizontally from the starting line to record video. The tripod height was adjusted based on the participant's individual characteristics to align with the height from the ground to the greater trochanter. A 1.5-meter high marker pole was placed at the starting line, with the start and end frames recorded when the participant's greater trochanter overlapped with the vertical marker pole.

Run-Shuffle-Run

The participant starts at the baseline, sprinting 8.32 meters and placing one foot on the designated line. The participant then performs a leftward backward shuffle, touches the cone marker with their left hand, then performs a rightward backward shuffle and touches the cone marker with their right hand. Finally, the participant sprints toward the marker at 8.32 meters and crosses the vertical marker on the designated line to stop the timing[15]. Each participant performs the test three times, with a 3-minute rest interval between each test[18]. The fastest time is recorded for data analysis. During the RSR test, a researcher places an iPhone on a tripod 5 meters vertically from the endpoint, 10 meters from the starting line. The tripod height for each participant is personalized to match the floor-to-greater-trochanter height. A vertical marker (a 1.5-meter-

long stick) is placed at the endpoint, and the researcher responsible for video analysis selects the moment the participant's finger leaves the cone at the start as the first frame. The last frame is when the greater trochanter crosses the midpoint of the vertical marker at the endpoint.

Lane test

The participant starts at the upper left corner of the free throw line and runs forward to the baseline (5.8 meters), then shuffles to the right along the baseline for 4.9 meters. Next, the participant runs backward to the upper right corner of the free throw line, then shuffles leftward for 4.9 meters, touching the designated spot with their foot. Afterward, the participant immediately reverses and repeats the same cycle[15]. The timing stops when the participant returns to the starting point. Each participant completes three trials, with a 3-minute rest interval between each test, and the fastest time is recorded for subsequent data analysis. A researcher places an iPhone on a tripod 5 meters vertically from the starting point and 5 meters from the starting line for video recording. The tripod height is adjusted according to the participant's individual characteristics to match the floor-to-greater-trochanter height. A vertical marker (1.5 meters in height) is placed at the starting line, and the starting and ending frames are defined as the moment the participant's hip center with the vertical marker.

10-m Sprint

The endpoint of the 505 test is set as the endpoint of the 10-m sprint. Vertical markers are placed at both the starting and finishing points. The participant stands behind the starting line, placing their hands on any part of the cone before starting. The starting and ending frames are defined as the moment when the participant's hip joint center overlaps with the vertical marker. Each participant completes three trials, with a 60-second rest interval between each test. The fastest time from the three trials is recorded for subsequent data analysis[16].

Statistical Analyses

Descriptive data are presented as means $\pm$ standard deviation (SD). The normality and homogeneity of variance of the data were assessed using the Shapiro-Wilk and Levene tests, respectively. Reliability was evaluated using the intraclass correlation coefficient (ICC) with 95% confidence intervals (95% CI) for absolute agreement and the coefficient of variation (CV)[3]. ICC was interpreted in line with Koo and Li, where values excellent were > 0.9 , good $0.75-0.9$, moderate $0.5-0.75$ and poor < 0.5 [30]. The acceptable CV is $<10\%$ [3]. The dominant side was defined as the side with better performance, while the non-dominant side was defined as the side with poorer performance[3]. The asymmetry index for dominant (D) and non-

202 dominant (ND) limbs was calculated as follows: Asymmetry Index = $(D-ND) / D \times 100\%$ [3]. Independent
203 samples t-tests were used to compare the differences between D and ND for all performance measures.
204 Considering the bias correction and the relatively small sample size in each group after grouping, as well as
205 the unequal number of male and female participants., Hedges' g was used as the effect size (ES) measure to
206 obtain more accurate and unbiased estimates, defined as small (<0.2), medium ($0.2-0.5$), and large (>0.8)
207 mean differences. Considering that asymmetry index in each test may reflects different physical abilities as
208 a ratio data. a standardized method was used for grouping[32]. Players were classified into high and low
209 asymmetry groups based on their asymmetry levels, following the approach used in previous studies[31,32].
210 Based on the asymmetry scores from 5-m shuffle, SLCMJ, SLLJ, CODD, and 505, participants were divided
211 into high asymmetry (HAG, $n=18$) and low asymmetry (LAG, $n=18$) groups using the median split[2].
212 Considering that the asymmetry index does not follow a normal distribution, independent samples and Mann-
213 Whitney U tests were used to assess the differences in asymmetry scores and directional performance
214 between HAG and LAG, as well as between boys and girls. Spearman's ρ correlation was used to examine
215 the relationships between asymmetry data and directional performance. The strength of correlations between
216 test variables was classified as trivial (≤ 0.1), small ($0.1-0.3$), moderate ($0.3-0.5$), large ($0.5-0.7$), very large
217 ($0.7-0.9$), and nearly perfect ($0.9-1.0$)[33]. All statistical analyses were performed using IBM SPSS Statistics
218 software version 27.0 (IBM, Armonk, NY, USA).

Results

All tests demonstrated acceptable CV (all < 10%) and exceptionally high ICC (all > 0.90) (Table 1). Table 2 presents the performance of the D and ND limbs in single leg jump, shuffle and COD tests, all of which showed significant differences between the D and ND sides (all $p < 0.01$). The asymmetry score for CODD reached 15.16%, the highest among all asymmetry tests. No significant correlations were found between asymmetry scores in any test and COD performance (all $p > 0.05$).

INSERT TABLE ONE HERE

INSERT TABLE TWO HERE

Figure 1 compares the differences in COD performance between the asymmetry and symmetry groups for each test. The median asymmetry values for each test are as follows: 5-m shuffle: 5.05%, SLCMJ: 7.9%, SLLJ: 5.93%, CODD: 13.68%, 505 test: 2.55%. Grouping based on CODD showed a significant difference in RSR performance ($p < 0.05$), with a medium to large effect size ($ES = 0.74$). Similarly, grouping based on shuffle asymmetry revealed a significant difference in T-test performance ($p < 0.05$), also with a medium to large effect size ($ES = 0.74$), suggesting that the asymmetry grouping had a notable impact on performance. The individual inter-limb asymmetry data for CODD and shuffle are showed in Figure 2.

Table 3 compares the differences in performance and asymmetry scores between male and female athletes. Except for CODD, male athletes outperformed female athletes in all tests (all $p < 0.05$).

INSERT FIGURE ONE HERE

INSERT TABLE THREE HERE

Discussion

The aims of this study were to: 1) assess side-to-side asymmetry in shuffle, CODD, and single-leg jumps among collegiate basketball players, and 2) examine the relationship between these resultant asymmetries and COD performance; in addition to examining the difference in COD performance between high and low asymmetry groups. Our findings indicate that CODD exhibited the highest asymmetry score. No test asymmetry was significantly correlated with COD performance. Grouping based on CODD asymmetry showed a significant difference in RSR performance, while grouping based on shuffle asymmetry also revealed a significant difference in T-test performance. These results consistent with our hypothesis.

CODD exhibited the highest asymmetry score, consistent with previous studies, indicating that CODD is a more sensitive measure for assessing COD asymmetry compared to total time[17,18]. Additionally, when grouping our sample based on high and low CODD asymmetry, differences in RSR performance were observed, with a medium-to-large effect size ($ES = 0.74$). This suggests that athletes with greater COD deficits exhibit meaningfully slower COD ability. This may be because CODD reflects an athlete's isolated change-of-direction ability by removing the influence of initial sprinting, which likely plays a decisive role in each lateral cut during the RSR test. This further supports CODD as an effective indicator for assessing COD speed[34,35]. Since most COD speed tests involve lateral cutting and COD, CODD appears to be the best indicator for evaluating this ability. We also found that CODD was the only metric without a sex difference among athletes. This may suggest that CODD is a measure of an individual's intrinsic ability, as it is a more relative value derived by subtracting sprint time from the 505 test time.

Shuffle asymmetry grouping yielded a significant difference in T-test performance ($p < 0.05$, $ES = 0.72$), indicating that greater lateral movement imbalance is associated with poorer performance in multidirectional COD tasks. Although not statistically significant, a moderate effect size ($ES = 0.56$) in RSR performance suggests that shuffle asymmetry may impair performance in tasks involving frequent shuffle actions. Considering that for basketball players, shuffle performance is crucial, especially during defense[13], performance on the weaker side may lead to defensive errors[29]. Assessing shuffle asymmetry and targeting the weaker side may help optimize movement efficiency and COD performance in basketball players. In addition, grouping athletes based on 505 asymmetry revealed moderate ES differences in both RSR and T-test performance, and similarly grouping based on SLCMJ asymmetry showed notable differences in Lane performance. Coaches and practitioners should also consider the practical application of these assessments, particularly across sports with varying movement demands[13]. Results also found that sex had a significant

impact on most COD test results, with female athletes generally exhibiting lower performance scores in several tasks. These differences may be attributed to both innate and acquired distinctions between sexes in terms of muscle mass, explosive strength, neuromuscular control, and training experience[36]. Males typically possess greater muscular strength and power, which may give them an advantage in tests involving rapid changes of direction, acceleration, and deceleration[37]. To address these disparities, coaches are advised to incorporate targeted training for female athletes focusing on lower-limb strength.

Our results showed that there were no significant correlation between asymmetry index and COD performance. This finding is inconsistent with previous studies. For example, Arboix-Alió et al. found that greater asymmetry in elite female basketball players was significantly associated with slower COD performance (p range = -0.67 to 0.57)[7]. One possible explanation for this discrepancy is that we employed more complex asymmetry assessments, whereas their study used the single-leg drop jump test. Asymmetry indices derived from different tests may reflect distinct physical capacities. The asymmetry index is a type of ratio data that measures the degree of performance difference between limbs during specific movement tasks, rather than the overall quality of performance itself[38]. For example, SLCMJ showed a higher asymmetry index but only a moderate effect size, whereas the 5-meter shuffle had a lower asymmetry index yet a larger effect size. This may also be one of the reasons why the asymmetry index was not significantly correlated with COD performance[39]. Thus, the asymmetry index should be considered an influencing factor, not a direct indicator of performance.

All our tests were conducted using phone app. Numerous previous studies have utilized mobile apps for testing[24,28,40], and our results show that accurately identifying start and end frames makes smartphone assessments of jump and COD performance reliable and consistent. This approach can help practitioners expand the diversity of their testing methods and enable simultaneous testing in the field using multiple mobile devices. This can be a useful option for teams with limited financial resources to conduct regular team strength and conditioning and performance tests. However, it is important to acknowledge that while mobile apps offer practical, cost-effective solutions for field testing, they cannot fully replace high-resolution motion capture systems or force platforms which remain the gold standard for detailed biomechanical analysis. Thus, app-based findings should be interpreted with caution and validated against laboratory assessments to ensure accuracy and reliability.

Based on the findings of this study, it is recommended that coaches incorporate assessments of CODD and lateral shuffle asymmetry as key indicators in routine training and conditioning evaluations. Special

attention should be given to enhancing the function of the weaker side through targeted COD and shuffle drills to optimize overall movement performance and movement efficiency[26]. Regular monitoring of these metrics allows coaches to objectively identify weaknesses in strength or coordination on one side of the body and effectively track improvements throughout the training process. Assessments can be integrated into long-term, in-season physical testing routines, conducted monthly or every four weeks[41]. Asymmetry can be calculated from strength, power, COD, and sport-specific performance tests. For athletes with marked shuffle asymmetry, lateral strength and power training (such as unilateral lateral bounds, adduction, and side lunges) should be included 2–3 times per week [42]. Coaches should specifically incorporate unilateral strength training into their programs, focusing on strengthening the weaker side's muscle groups[43].

This study has some limitations which should be noted. First, we only conducted predetermined-route COD speed tests and did not include reactive (unanticipated) COD speed tests. Future research could explore the relationship between asymmetry and unanticipated COD speed performance. Second, the COD speed tests used in this study had different proportions of linear acceleration and shuffle movements. Future studies should aim to design CODS assessments that better reflect the specific movement demands of basketball players. Third, the relatively small sample size may limit the statistical power to detect differences between high and low asymmetry groups and we acknowledge that dichotomizing a continuous variable using a median split may reduce statistical power and obscure potentially meaningful variability within the data. However, it is worth noting that all participants were from the same university team and followed a consistent training schedule, which helped control for variability in training background and enhanced the internal validity of the findings. Future studies with larger sample sizes are needed to validate these findings and improve statistical power.

In conclusion, our findings suggested that basketball players with high CODD and shuffle asymmetry may have poorer COD performance. Practitioners should use CODD and shuffle assessments to specifically evaluate asymmetry in basketball players and target training in these two areas to improve CODS performance.

Table 1. Reliability data for shuffle, single leg jump, COD tests with dominant (DL) and non-dominant (NDL) legs

Test		CV (95% CI)	ICC (95% CI)
5-m shuffle (s)	DL	2.5 (1.74, 3.26)	0.96 (0.93, 0.98)
	NDL	2.2 (1.69, 2.71)	0.97 (0.95, 0.98)
SLCMJ (cm)	DL	6.4 (4.96, 7.84)	0.98 (0.97, 0.99)
	NDL	6.3 (5.20, 7.40)	0.97 (0.94, 0.98)
SLLJ (cm)	DL	4.1 (3.34, 4.86)	0.97 (0.95, 0.98)
	NDL	4.4 (3.47, 5.33)	0.96 (0.93, 0.98)
505 (s)	DL	1.8 (1.29, 2.31)	0.93 (0.89, 0.96)
	NDL	1.9 (1.48, 2.32)	0.95 (0.92, 0.97)
10-m (s)		1.8 (1.29, 2.31)	0.96 (0.93, 0.98)
T-test (s)		1.5 (1.16, 1.84)	0.96 (0.92, 0.98)
RSR (s)		1.4 (1.06, 1.74)	0.98 (0.96, 0.99)
Lane (s)		2.5 (1.99, 3.01)	0.96 (0.94, 0.98)

Abbreviation: SLCMJ, single leg countermovement jump; SLLJ, single leg lateral jump; CODD, change of direction deficit; DL, dominant limb; NDL, non-dominant limb.

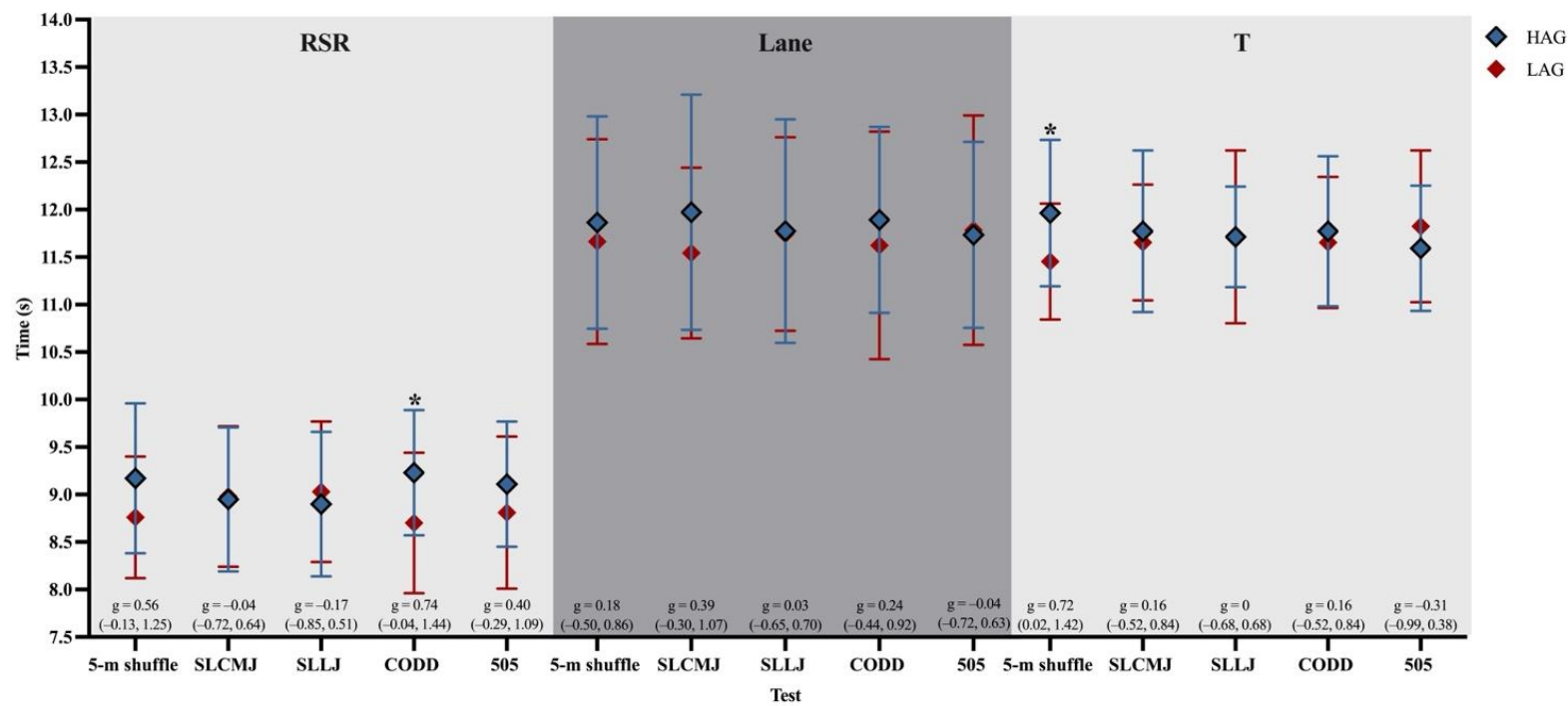
Table 2. Jump, shuffle, change of direction performance and asymmetry score.

Test	DL	NDL	ES (95% CI)	Asymmetry (%)
5-m shuffle (s)	1.68 ± 0.17**	1.78 ± 0.18	−0.57 (−0.18, −0.02)	5.47 ± 3.68
SLCMJ (cm)	17.98 ± 5.65**	16.07 ± 4.81	0.36 (−0.56, 4.37)	10.09 ± 8.24
SLLJ (cm)	147.67 ± 20.94**	138.89 ± 18.76	0.44 (−0.57, 18.12)	5.81 ± 3.49
505	2.59 ± 0.17**	2.67 ± 0.18	−0.45 (−0.16, 0.01)	2.77 ± 2.29
CODD(s)	0.41 ± 0.09**	0.49 ± 0.09	−0.81 (−0.12, −0.03)	15.16 ± 12.18

Abbreviation: SLCMJ, single leg countermovement jump; SLLJ, single leg lateral jump; CODD, change of direction deficit; DL, dominant limb; NDL, non-dominant limb.

** = significantly different to the test on the non-dominant limb ($p < 0.01$)

Figure 1. The difference of change of direction performance between asymmetry and symmetry group in each test.



Abbreviation: SLCMJ, single leg countermovement jump; SLLJ, single leg lateral jump; CODD, change of direction deficit; RSR, run shuffle run; HAG, high asymmetry group; LAG, low asymmetry group; g, effect size.

* = significant difference between high and low asymmetry group ($p < 0.05$)

Table 3. The differences in single leg jump heights, shuffle, change of direction performance and asymmetry index between male and female athletes.

	Female	Male	ES (95% CI)	<i>p</i>
S5-L (s)	1.76 ± 0.16	1.63 ± 0.18*	0.75 (0.05, 1.46)	0.03
S5-R (s)	1.83 ± 0.15	1.69 ± 0.18*	0.84 (0.12, 1.55)	0.02
Asymmetry (%)	6.02 ± 4.19	4.79 ± 2.93	0.33 (−0.30, 1.07)	0.31
SLCMJ-L (cm)	13.67 ± 3.18	21.31 ± 4.73**	−1.90 (−2.72, −1.07)	< 0.001
SLCMJ-R (cm)	14.02 ± 4.30	20.72 ± 3.60**	−1.64 (−2.43, −0.84)	< 0.001
Asymmetry (%)	10.61 ± 9.10	9.47 ± 7.26	0.13 (−0.55, 0.82)	0.68
SLLJ-L (cm)	131.65 ± 15.46	157.44 ± 16.63**	−1.58 (−2.36, −0.80)	< 0.001
SLLJ-R (cm)	132.55 ± 14.97	157.06 ± 17.99**	−1.46 (−2.24, −0.69)	< 0.001
Asymmetry (%)	4.90 ± 3.30	6.95 ± 3.48	−0.60 (−1.29, 0.10)	0.08
CODD-L (s)	0.42 ± 0.10	0.46 ± 0.09	−0.41 (−1.10, 0.28)	0.20
CODD-R (s)	0.46 ± 0.11	0.47 ± 0.09	−0.10 (−0.78, 0.59)	0.72
Asymmetry (%)	15.92 ± 12.34	14.20 ± 12.32	0.14 (−0.55, 0.82)	0.68
L505 (s)	2.70 ± 0.16	2.51 ± 0.14**	1.23 (0.48, 1.97)	< 0.001
R505 (s)	2.74 ± 0.16	2.52 ± 0.13**	1.46 (0.69, 2.23)	< 0.001
Asymmetry (%)	2.71 ± 2.15	2.84 ± 2.51	−0.06 (−0.74, 0.63)	0.87

Abbreviation: S5, shuffle test at 5 m; SLCMJ, single leg countermovement jump; SLLJ, single leg lateral jump; CODD, change of direction deficit; RSR, Run shuffle Run.

** = $p < 0.001$; * = $p < 0.05$

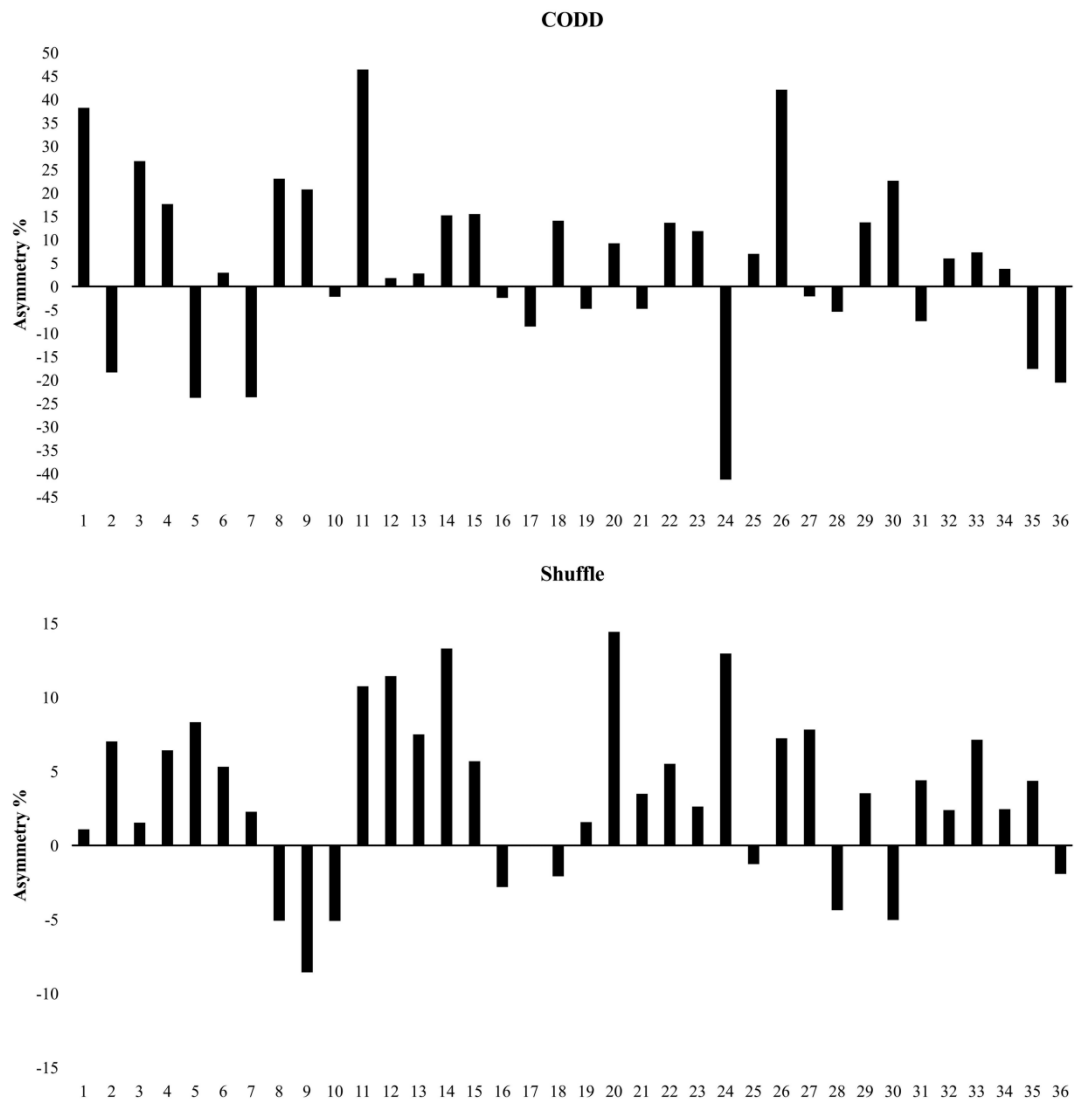


Figure 2. Individual inter-limb asymmetry data for change of direction deficit and shuffle. Note: Above 0 means the asymmetry favors the dominant limb, and below 0 means the asymmetry favors the non-dominant limb.

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