Change-of-Direction Deficit vs. Deceleration Deficit: A Comparison of Limb Dominance and Inter-limb Asymmetry between Forwards and Backs in Elite Male Rugby Union Players

Running head: COD and deceleration deficit in rugby players

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Abstract

The aims of the present study were to: 1) determine whether limb dominance and inter-limb asymmetry were the same across both change of direction (COD) and deceleration (DEC) deficits and, 2) determine the association between the COD and DEC-deficits and other physical performance tests in elite male rugby union players. Twenty five players performed a series of bilateral jumps, linear and COD speed tests at the end of the pre-season period. COD and DEC-deficits were calculated for both left and right sides, and inter-limb asymmetry thereafter. Kappa coefficients revealed moderate levels of agreement in limb dominance between COD and DEC-deficits (Kappa = 0.41 on left; 0.48 on right). For the direction of asymmetry, perfect levels of agreement (Kappa = 1) were evident between 505 time and COD-deficit, but only moderate levels of agreement (Kappa = 0.41) between other asymmetry measures. Pearson's *r* correlations showed moderate to large relationships between jumps and linear (r = -0.42 to -0.68) and COD speed (r = -0.41 to -0.58), but not with the COD-deficit (r = 0.15 to -0.31), DEC-deficit (r = 0.01 to -0.32) or asymmetry (r = 0.16 to -0.29). When analyzing by playing position, backs were significantly faster than forwards over 15-m (ES = -0.86) and across all jump tests (ES = 0.86-0.94), with the exception of the squat jump. This study is the first to provide a direct comparison of the COD and DEC-deficits and highlights that limb dominance and asymmetry cannot be guaranteed between tasks.

Key Words: Kappa coefficient; left vs. right; team sports.

Introduction

Change of direction (COD) speed is one of the most important physical qualities for team sport athletes (Nimphius et al. 2013; Nimphius et al. 2016; Sheppard and Young, 2006). Typically, COD maneuvers consist of decelerating prior to an actual COD, with a subsequent re-acceleration, often in response to an external stimulus (Young et al. 2002). When considering the prevalence of COD in team sports, it has been shown that elite soccer players can change direction between 1200-1400 times during a single match (Bangsbo, 1992) and up to ~170 high-intensity actions (inclusive of accelerating and decelerating) also occurring during match-play (Taylor et al. 2017). Likewise, in rugby union, average sprint duration ranges from 2.01-2.07s for forwards vs. 2.53-3.84s for backs (Deutsch et al. 2007) indicating a short period of time is spent accelerating prior to decelerating and changing direction. Thus, given the frequency of COD actions in sport, testing this physical quality for team sport athletes is strongly suggested (Freitas et al. 2019; Nimphius et al. 2013; Nimphius et al. 2016; Turner and Stewart, 2014).

Recently however, the use of total time as the sole metric during COD tasks has come under some critique. Specifically, Nimphius et al. (2013) has advocated that some athletes can disguise poor COD ability by their superior linear accelerating capacity. As such, the use of total time as an outcome measure during COD tasks may have limitations, which has been also indicated in recent empirical research (Madruga-Parera et al. 2019). Consequently, the "COD-deficit" has been suggested as a viable and useful metric for practitioners and researchers. This involves subtracting the time it takes to complete a linear sprint from the time it takes to complete a COD task of equivalent distance (e.g., 10m sprint time subtracted from 505 time). Once computed, it is hypothesized that the COD-deficit provides a more appropriate measure of an athlete's ability to change direction, when compared to the metric of total time. Furthermore, this has become a popular and increasingly important line of investigation in recent years (Bishop et al. 2020a; Dos'Santos et al. 2019; Loturco et al. 2018; Nimphius et al. 2013; Nimphius et al. 2016).

Similar to the COD-deficit, a new method of determining an athlete's deceleration ability has been proposed, termed the "deceleration deficit" (DEC-deficit) (Clarke et al. 2019). Limited literature exists on this measure to date; however, the proposed calculation of this metric can be achieved by including a 505 test (with the addition of a contact mat or an optical measurement system at the turning point of the test) and the inclusion of a 15-m linear sprint. The equation to calculate the DEC-deficit is: (time taken from 0-15-m during the 505 test + 50% of the ground contact time [GCT]) – best 15-m linear sprint time (Clarke et al. 2020a; Clarke et al. 2020b). The justification for adding on 50% of the GCT is because previous research has shown that 50% of a 180° turn can be accounted for from the actual GCT of the turn, with the remaining 50% being accounted for by technique and physical characteristics such as speed and strength (Clarke et al. 2020a; Clarke et al. 2020b). Furthermore, rugby union players are exposed to frequent COD movement patterns (Nakamura et al. 2016), with previous research showing that the assessment of this physical component is able to differentiate between playing abilities (Green et al. 2011).

Both the DEC-deficit and COD-deficit have been proposed to be calculated using the 505 test which involves a 180° turn. As such, data from both left and right limbs are available during these assessments, enabling practitioners to gauge an understanding of limb dominance (i.e., which limb is faster) during COD actions. This has been shown in recent research from Dos'Santos et al. (2019), who demonstrated that the COD-deficit was a more sensitive measure of detecting existing inter-limb asymmetries than total time. However, to date, no study has provided such information for the DEC-deficit or a direct comparison between these practical COD derived measures (i.e., COD-deficit and DEC-deficit).

Therefore, the primary aim of the present study was to determine whether limb dominance was the same across both COD and DEC-deficits. A secondary aim was to determine the association between the COD and DEC-deficits and their associated asymmetries with other physical performance tests in elite male rugby union players. Given no literature relating to the DEC-deficit has been conducted to date, developing a true hypothesis was challenging. Nevertheless, numerous studies to date have highlighted the task-specific nature of limb dominance (Bishop et al. 2018; Bishop et al. 2019; Dos'Santos et al. 2019; Madruga-Parera et al. 2019); thus, it was hypothesized that the same limb would not always be favoured between both measurements. Furthermore, previous literature has highlighted inconsistent findings when reporting associations between ratio numbers (i.e., a value made up of two component parts) and independent measures of performance (Bishop et al. 2020a). As a result, any meaningful correlations between these two deficit numbers and physical performance were hypothesized to be weak.

Methods

Study Design

This cross-sectional correlational study aimed to assess the COD and DEC-deficits in elite male rugby union players. Due to the constant training and assessments in our sports facilities, all athletes were well familiarized with the testing procedures. Players performed physical assessments on the same day, in the following order: squat, countermovement and drop jumps (SJ, CMJ, and DJ, respectively); 15-m linear sprint (with a split time for 10-m); 505 COD test; and maximum mean propulsive power (MPP) in the half squat (HS) and jump squat (JS) exercises. Prior to the tests, athletes performed standardized warm-up protocols including general (i.e., running at a moderate pace for 10 minutes followed by dynamic stretching for 5 minutes) and specific practice trials (i.e., submaximal attempts at 60, 80 and 100% of perceived maximal effort for each tested exercise).

Participants

Twenty-five elite male rugby union players (*Group*: age: 26.5 ± 3.8 years, body mass [BM]: 102.9 ± 15.7 kg, height: 189.1 ± 4.8 cm; *Backs*: n = 12, age: 24.3 ± 3.4 years, body mass: 91.0 ± 10.6 kg, height: 182.3 ± 6.9 cm; *Forwards*: n = 13, age: 25.2 ± 3.1 years, body mass: 112.5 ± 11.4 kg, height: 186.4 ± 9.2 cm) from the same professional team, participated in the present study. A priori power analysis identified that when aiming to assess differences between two independent groups at a statistical power of 0.8, with an alpha level of 0.05 and effect size of 0.8, 21 athletes were required for each group. Thus, the present study is under-powered. However, it is worth noting that the present group were professional athletes and studies using such samples are likely to be under-powered given the limited number of athletes associated with any single organisation. Players were tested in the final phase of preparation for the beginning of the South American Rugby Super League. All players had a minimum of 8 years' competitive rugby experience and 5 years' experience with structured strength and conditioning training. No injuries were reported at the time or in the preceding 6 weeks prior to testing. The study was approved by the local Ethics Committee and all subjects were informed of the inherent risks and benefits associated with study participation, before signing informed consent forms.

Procedures

Vertical Jumps

Vertical jumping ability was assessed using the SJ, CMJ, and DJ, with all jumps executed with the hands positioned on the hips. In the SJ, a static position with a 90° knee flexion angle was maintained for 2-s before a maximal effort jump without any preparatory movement, which was visually monitored by two members of the research team. In the CMJ, the players were instructed to perform a downward movement followed by a rapid extension of the lower limbs and the amplitude of the countermovement was freely determined to avoid changes in the jumping coordination pattern. In the DJ, participants were instructed to step off a 30-cm box with knees and ankles fully extended and land in a similarly extended position to ensure the validity of the test. Specific instructions were provided to "jump as high as you can" for the SJ and CMJ tests and, "minimize ground contact and jump as high as you can" for the DJ. Five attempts at each jump were performed interspersed by 30-s rest intervals. Jump tests were performed on a contact mat (Elite Jump®, S2 Sports, São Paulo, Brazil), which was positioned on flat fitted rubber gym flooring. The highest jump (calculated from the flight time method) was used for data analysis purposes in the SJ and CMJ. For the DJ, the best reactive strength index

(RSI) was taken from the jump height divided by the ground contact time before the take-off.

15-m Linear Sprint

Three pairs of photocells (Smart Speed, Fusion Equipment, Brisbane, AUS) were positioned at a height of 1-m at the starting line and at the distances of 10 and 15-m along an indoor athletics track. Athletes sprinted twice in athletic footwear of their choice (which was consistent for all test protocols), starting from a 2-point staggered stance position 0.5-m behind the starting line with sprint time recorded to the nearest 0.01-s. Specific test instructions were to “sprint as fast as possible through the photocells”. A 5 minute rest interval was allowed between the two attempts and the fastest time was considered for the final analyses.

505 Change of Direction Test, COD-Deficit and DEC-Deficit.

Conditions for the 505 test (i.e., height of photocells, surface of testing and footwear used) were the same as the linear speed assessment. Players started from a 2-point staggered stance position with the front foot placed 0.5-m behind the first pair of photocells (Smart Speed, Fusion Equipment, Brisbane, Australia). The second pair of photocells was positioned at 10-m, and a contact mat (Smart Jump, Fusion Equipment, Brisbane, Australia) was set at the distance of 15-m from the starting line (Figure 1), heavily taped to the floor to avoid any un-wanted movement during turning. Players were instructed to sprint to the contact mat, placing either their right or left foot on the line (drawn in the middle of the mat), perform a 180° turn and sprint back through the finishing line (10-m photocells). The time from the 10-m gate to the 15-m contact mat and back to the 10-m gate was recorded for the 505 COD time for left and right sides. The time from the starting line to the contact mat was recorded to calculate the 15-m deceleration time. Two attempts were performed for each side (conducted in a randomized order) and the best 505 and 15-m deceleration attempts were used for analysis. The COD-deficit was calculated based on the difference between 10-m linear sprint and 505 COD times (Nimphius et al. 2013; Nimphius et al. 2016; Pereira et al. 2018). The DEC-deficit was calculated as difference between 15-m linear sprint and 15-m deceleration times (+ 50% GCT) (Clarke et al. 2019).

***** Insert Figure 1 about here *****

Bar Power Outputs in Half Squat and Jump Squat Exercises

Maximum MPP outputs were assessed in HS and JS, all performed on a Smith machine (Hammer Strength Equipment, Rosemont, IL, USA) as previously described (Loturco et al. 2017a; Loturco et al. 2017b; Sanchez-Medina et al. 2010). Players were instructed to execute two repetitions at maximal velocity for each load, starting at 40% of their BM. A load of 10% BM was gradually added until a decrease in MPP was observed. A 5 minute interval between sets was provided. To determine the MPP, a linear position transducer (T-Force, Dynamic Measurement System; Ergotech Consulting S.L., Murcia, Spain) was attached to the Smith machine bar and values were automatically derived by the custom-designed software. The bar position data were sampled at 1,000 Hz. The maximum MPP values obtained in each exercise were used for subsequent analysis. Values were normalized by dividing the absolute power by the athletes' BM (i.e., relative power = $W \cdot kg^{-1}$).

Statistical Analyses

Data are presented as means and standard deviation (SD). Normality of data was confirmed via the Shapiro-Wilk for raw test scores, but not for asymmetry data. Absolute and relative reliability of test measures were computed using the coefficient of variation (CV) and a two-way random intraclass correlation coefficient (ICC) with absolute agreement and 95% confidence intervals, respectively. CV values ≤ 10% were deemed acceptable (Cormack et al. 2008) and ICC was interpreted in line with suggestions from Koo and Li, (2016) where: > 0.9 = excellent; 0.75-0.9 = good; 0.5-0.74 = moderate and < 0.5 = poor.

Inter-limb asymmetry was calculated between left and right using the formula: 100÷(maximum value)*(minimum value)*-1+100 as used in numerous empirical studies investigating inter-limb differences (Bishop et al. 2018; Bishop et al. 2019; Bishop et al. 2020a; Bishop et al. 2020b). When considering 505 time, COD and DEC-deficits, Kappa coefficients were used to determine levels of agreement for both limb dominance and the direction of asymmetry between tasks. This analysis was performed as it determines levels of agreement after any agreement that may have occurred by chance (Cohen, 1960). Kappa coefficients were interpreted in line with Viera and Garrett, (2005) where: 0-0.2 = slight; 0.21-0.4 = fair; 0.41-0.6 = moderate; 0.61-0.8 = substantial; 0.81-0.99 = nearly perfect and 1 = perfect levels of agreement.

Positional differences (i.e., between forwards and backs) were assessed using an independent samples t-test, with statistical significance set at $p < 0.05$. Hedges g effect sizes were also calculated providing an indication of the magnitude of difference between groups. Values were interpreted in line with suggestions from Hopkins et al. (2009) where: < 0.2 = trivial; 0.2-0.6 = small; 0.61-1.2 = moderate; 1.21-2.0 = large and 2.01-4.0 = very large. Finally, Pearson (r) product moment correlations were performed to determine the relationships between fitness tests, and Spearman's rank order (ρ)

correlations used to determine the relationship between asymmetry scores and jump data, with statistical significance set at $p < 0.05$. R values were qualitatively interpreted as follows: < 0.09 = trivial; 0.10-0.29 = small; 0.30-0.49 = moderate; 0.50-0.69 = large; 0.70-0.89 = very large and > 0.90 = nearly perfect (Hopkins et al. 2009).

Results

Table 1 shows absolute and relative reliability data by group and playing position, with all measures exhibiting CV values ≤ 13.7%. Slightly elevated CV values (> 10%) were present for GCT and DEC-deficit metrics. For relative reliability, all metrics ranged from moderate to excellent with ICC values ranging from 0.67-0.99.

Table 2 shows mean test and SD data for the whole group and split between forwards and backs. Backs outperformed forwards during the 15-m (ES = -0.86; $p < 0.05$), CMJ (ES = 0.86; $p < 0.05$), RSI (ES = 0.90; $p < 0.05$), HS (ES = 0.94; $p < 0.05$) and JS (ES = 0.92; $p < 0.05$) exercises. No other significant differences were evident between groups. Figures 2 and 3 show individual player COD and DEC-deficit times for the left and right limbs, respectively. When assessing limb dominance between measures, Kappa coefficients revealed moderate levels of agreement between the COD-deficit and DEC-deficit for the left (Kappa = 0.41) and right (Kappa = 0.48) limbs.

Mean asymmetry was 4.32 ± 3.29% for 505 time, 31.24 ± 20.81% for COD-deficit and 11.64 ± 9.69% for DEC-deficit, and Figure 4 shows individual player inter-limb asymmetry values for these three metrics. Kappa coefficients were used to determine levels of agreement for the direction of asymmetry and revealed perfect agreement (Kappa = 1) between 505 time and COD-deficit and moderate agreement (Kappa = 0.41) between both the 505 and DEC-deficit, and COD-deficit and DEC-deficit metrics.

Table 3 shows the correlations between jump data and 10-m, 15-m, 505, COD-deficit and DEC-deficit times. Significant correlations were evident between SJ and speed and 505 performance (r = -0.43 to -0.60), CMJ and speed and 505 performance (r = -0.53 to -0.61), HS-MPP and speed and 505 performance (r = -0.43 to -0.68) and JS-MPP and speed and 505 performance (r = -0.41 to -0.53). No significant relationships were evident between jump scores and COD or DEC-deficit on either limb. Table 4 shows the correlations between jump data and 505, COD-deficit and DEC-deficit asymmetry metrics. No significant relationships were evident (ρ range = 0.16 to -0.29).

***** Insert Tables 1-4 about here *****

***** Insert Figures 2-4 about here *****

Discussion

The aims of the present study were to: 1) determine whether limb dominance was the same across both COD and DEC-deficits and, 2) determine the association between the COD and DEC-deficits and their associated asymmetries with other physical performance tests in elite male rugby union players. Kappa coefficients revealed moderate levels of agreement between the COD and DEC-deficits for limb dominance. Significant relationships were evident between jump scores and speed or 505 performance, but not with the COD-deficit, DEC-deficit or inter-limb asymmetries.

This study is the first to provide a direct comparison for limb dominance characteristics between the COD and DEC-deficits. Both limbs showed only moderate levels of agreement between tasks (Kappa = 0.41 on left; 0.48 on right), which indicates that the faster performing limb sometimes 'switched sides'. Whilst no mechanistic investigation was undertaken to determine why this might be the case, recent literature on COD speed has indicated that when performing 180° turns, strong braking strategies are required in the preceding steps before the turn (Thomas et al. 2019), especially the penultimate foot contact (Dos'Santos et al. 2018). Thus, it is possible to speculate that the steps during the approach phase of the turn may play a large part in determining the outcome of the COD and DEC-deficits. Furthermore, in order to fully determine why faster times often align to different limbs, a more in-depth look at COD strategy is likely required. With that in mind, future research should consider investigating metrics such as entry and exit velocity of the turns (Dos'Santos et al. 2018), in addition to some kinematic information such as knee abduction angle, which has been shown to elicit notable side-to-side differences in a recent empirical investigation (Thomas et al. 2020). It is also worth noting that moderate levels of agreement between tasks (via the Kappa coefficient) has been noted in recent research using jump tasks in elite male academy (Bishop et al.

2020b) and youth female soccer players (Bishop et al. 2019). Thus, it appears that consistency in limb dominance is rare for both COD and jumping actions and may be a “natural product” of movement variability.

Kappa coefficients were also used to determine levels of agreement in the direction of asymmetry. Unsurprisingly, perfect levels of agreement (Kappa = 1) were evident between 505 time and COD-deficit, which can be explained by the calculation of the COD-deficit. Although separate values can be calculated for left and right limbs, the linear sprint time is used for the creation of both COD-deficit values. In essence, the absolute difference between left and right sides will remain the same for both total time and the COD-deficit. For example, if an athlete exhibited scores of 2.0 and 2.2-s for left and right limbs on the 505 test, the difference is 0.2-s. If a 10-m time of 1.7-s is then subtracted, we are left with COD-deficit values of 0.3 and 0.5-s, which still results in an absolute difference of 0.2-s. Thus, with the direction of asymmetry merely looking at which limb the percentage value favours, this will never change once the COD-deficit calculation has occurred, resulting in perfect levels of agreement between these two metrics. In contrast, only moderate levels of agreement (Kappa = 0.41) were evident between these two metrics when compared with the DEC-deficit, again highlighting how the direction of asymmetry sometimes swapped sides between COD and DEC tasks. This is further supported by Figure 4, which shows that some athletes (e.g., 7, 8 and 9) exhibited superior performance on opposite sides for the COD and DEC-deficit tasks. With only moderate levels of agreement, it highlights the independent nature of these two metrics, both of which may provide practitioners with useful information when profiling COD performance in their athletes.

It is also worth noting, the smaller absolute values for the COD-deficit also serve as the reason why asymmetry scores are so much larger compared to total time. Previous research has indicated that total time during the 505 test is not very sensitive at detecting inter-limb differences (Madruga-Parera et al. 2019), and that the COD-deficit may be a better measure of detecting asymmetry (Dos'Santos et al. 2019). However, with asymmetry being reported as a percentage difference, and therefore being a relative concept, the smaller values shown for the COD-deficit (compared to total time during the 505 test), will always exhibit much larger asymmetries. Practitioners should be mindful of this concept and not get drawn in to 'chasing perfect symmetry' for a metric that is likely to exhibit large side-to-side differences.

Table 2 shows correlations between jump variables, linear and COD speed, and the COD and DEC-deficits. All meaningful relationships were negative indicating that larger jump scores were associated with faster linear or COD speed. In addition, these correlations were all moderate to large in magnitude, which is in agreement with previous research investigating the correlations between bilateral jumping and linear and COD speed tests (Castillo-Rodriguez et al. 2012; Lockie et al. 2018). In contrast, no significant relationships were evident between jump scores and either COD or DEC-deficits and, to the authors' knowledge, no study has investigated the relationships between jump performance and these COD derived measures. However, the lack of meaningful relationships should not come as a complete surprise, given that recent literature has shown that associations between linear and COD speed rarely track consistently with other ratios, such as asymmetry scores (Bishop et al. 2020a; Loturco et al. 2019). This is likely because ratio numbers tend to show larger variability, which is supported in the current data. As observed in Table 1, the SD for 505 times (0.11-0.12-s) ranged from 5-6% of the group mean values (2.00-2.05-s). In contrast, the SD for COD and DEC-deficits ranged from 36-48% and 16-22% of the group means, respectively. Thus, with greater inherent noise typically seen in ratio data (Bishop et al. 2020a; Bishop et al. 2020b), it is probable that consistent significant relationships will not be evident.

Table 4 shows correlations between jump scores and COD asymmetry data. No significant relationships were evident indicating that the magnitude of inter-limb difference during COD tasks is independent of jump performance. Given the obvious difference between these two types of motor task, this does not seem surprising and is in agreement with the findings of some previous research on the topic (Lockie et al. 2014; Loturco et al. 2019).

The present study also determined differences by comparing test scores for forwards and backs. Backs outperformed forwards for all jump tests (except the SJ) and also for the 15-m sprint time, which should be seen as an expected result. Firstly, backs often perform much more sprints and COD based movements than forwards (Deutsch et al. 2007), in an attempt to evade opponents during attacking phases of play. Thus, it stands to reason they performed better than forwards on the 15-m test (ES = -0.86). Furthermore, backs also outperformed forwards for the majority of jump tasks, which is likely due to their improved power-to-weight ratio (as supported by the superior HS and JS relative scores). This has also been noted in previous research comparing backs vs. forwards (Comfort et al. 2011; Nakamura et al. 2016). In contrast, no meaningful differences were evident between groups for COD or DEC-deficit scores, which seems a somewhat surprising finding. However, this emphasizes the independent nature of linear and COD speed tests (Sheppard and Young, 2006) and highlights an area of physical development required for the backs in the present population.

Despite the novelty of the present study, it was not without its limitations. Firstly, data was only available for a single time point and, although data was collected towards the end of pre-season (i.e., without the accumulation of fatigue from competitive matches), longitudinal data would be more useful. This would enable seasonal variation to be quantified and whether existing relationships between jump, linear, and COD speed track consistently over time, which has been investigated in recent research (Bishop et al. 2020a; Bishop et al. 2020b). In addition, the sample used in the present study was relatively small and, consequently, these data can only be attributed to this particular rugby population. Given the relatively new concepts of the COD and DEC-deficits, further research is warranted using these metrics, but it is also suggested that future COD research focuses on strategy and biomechanical variables, as previously mentioned.

Conclusions

Our data highlight the largely independent nature of COD and DEC-deficits and suggest that the superior performing limb often varies between the two tasks. Given the common inclusion of devices such as contact mats or optical measurement systems in elite sport settings and the usual assessment of linear and COD speed performance in team sports, the calculation of both the COD and DEC-deficit seems to be a viable and useful option for practitioners and researchers. Together, these measures can provide a deeper and more comprehensive understanding of COD ability, allowing coaches to develop more efficient and tailored training strategies, based on the individual needs of each athlete and/or sport discipline.

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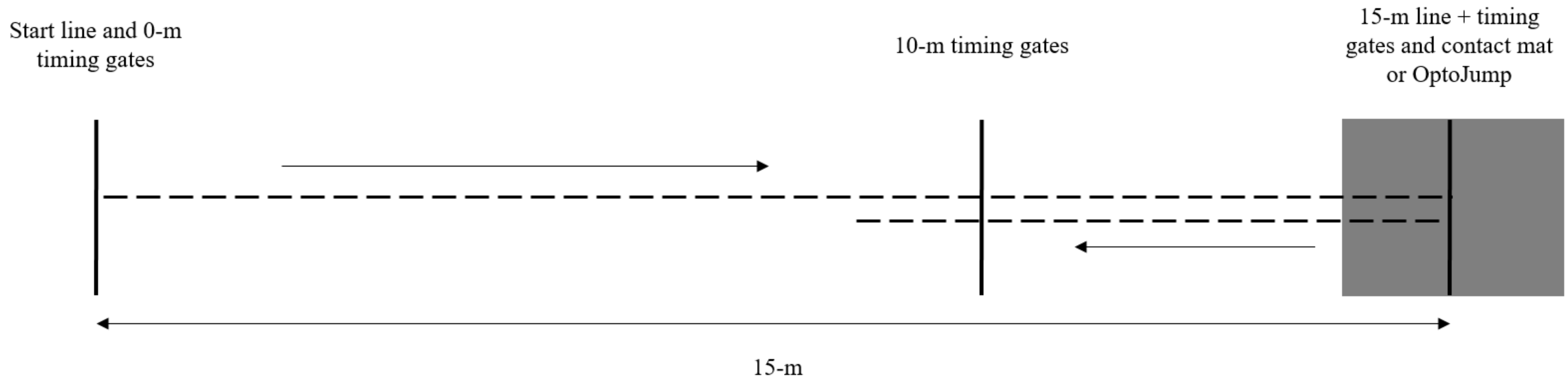

Figure 1. Schematic of the 505 test with the inclusion of either a contact mat or OptoJump to measure ground contact time during the 180° turn. Note: top 2 arrows indicate direction of travel. N.B.1: change of direction deficit is calculated as: 505 time – 10-m time. N.B.2: deceleration deficit is calculated as: (time taken from 0-15-m during the 505 test + 50% of the ground contact time) – best 15-m linear sprint time.

Table 1. Coefficient of variation (CV) and intraclass correlation coefficient (ICC) with 95% confidence intervals for the whole group and by playing position.

Fitness Test	**Whole Group (*n* = 25)**		**Forwards (*n* = 13)**		**Backs (*n* = 12)**	
	CV (%)	*ICC (95% CI)*	*CV (%)*	*ICC (95% CI)*	*CV (%)*	*ICC (95% CI)*
10-m	1.3	0.93 (0.83, 0.97)	1.4	0.87 (0.56, 0.96)	1.2	0.95 (0.85, 0.98)
15-m	1.1	0.96 (0.91, 0.98)	1.1	0.95 (0.81, 0.98)	1.1	0.97 (0.90, 0.99)
505-L	3.7	0.76 (0.47, 0.89)	4.5	0.67 (0.01, 0.90)	2.8	0.90 (0.68, 0.97)
505-R	3.5	0.80 (0.43, 0.94)	4.3	0.70 (0.23, 0.93)	2.7	0.91 (0.69, 0.98)
CODD-L	8.1	0.92 (0.78, 0.97)	6.2	0.90 (0.51, 0.98)	9.9	0.94 (0.76, 0.98)
CODD-R	8.1	0.94 (0.85, 0.99)	6.8	0.91 (0.54, 0.99)	9.3	0.95 (0.83, 0.99)
50% GCT-L	12.1	0.79 (0.52, 0.91)	11.0	0.81 (0.37, 0.94)	13.1	0.89 (0.60, 0.97)
50% GCT-R	12.8	0.75 (0.51, 0.87)	11.8	0.80 (0.33, 0.92)	13.7	0.86 (0.55, 0.93)
DECD-L	11.3	0.78 (0.49, 0.91)	9.9	0.87 (0.41, 0.97)	12.6	0.76 (0.25, 0.92)
DECD-R	10.7	0.75 (0.43, 0.95)	9.4	0.82 (0.49, 0.93)	11.9	0.74 (0.30, 0.86)
SJ	3.1	0.98 (0.97, 0.99)	2.8	0.99 (0.98, 0.99)	3.4	0.98 (0.96, 0.99)
CMJ	2.8	0.97 (0.95, 0.99)	3.0	0.96 (0.90, 0.99)	2.5	0.98 (0.96, 0.99)
RSI	8.6	0.92 (0.83, 0.96)	7.9	0.91 (0.75, 0.97)	9.2	0.89 (0.68, 0.97)
HS-MPP	4.5	0.98 (0.96, 0.99)	3.1	0.99 (0.98, 0.99)	5.9	0.97 (0.89, 0.99)
JS-MPP	4.1	0.98 (0.95, 0.99)	4.5	0.97 (0.89, 0.99)	3.6	0.98 (0.95, 0.99)

m = meters; L = left; R = right; CODD = change of direction deficit; GCT = ground contact time; DECD = deceleration deficit; SJ = squat jump; CMJ = countermovement jump; RSI = reactive strength index; HS = half squat; JS = jump squat; MPP = mean propulsive power.

Table 2. Mean and standard deviations (SD) for speed, change of direction (COD) speed, COD-deficit, DEC-deficit, and jump test data by group, forwards and backs. Hedges *g* effect sizes (95% confidence intervals) presented between forwards and backs.

Fitness Test	Whole Group (*n* = 25)	Forwards (*n* = 13)	Backs (*n* = 12)	Effect Size (*g*)
10-m (s)	1.77 ± 0.07	1.79 ± 0.09	1.75 ± 0.05	-0.53 (-1.20, 0.14)
15-m (s)	2.44 ± 0.10	2.48 ± 0.11	2.40 ± 0.06*	-0.86 (-1.55, -0.17)
505-L (s)	2.05 ± 0.11	2.07 ± 0.14	2.02 ± 0.07	-0.43 (-1.10, 0.23)
505-R (s)	2.00 ± 0.12	2.02 ± 0.13	1.99 ± 0.12	-0.23 (-0.89, 0.43)
CODD-L (s)	0.28 ± 0.10	0.29 ± 0.11	0.26 ± 0.09	-0.29 (-0.95, 0.37)
CODD-R (s)	0.23 ± 0.11	0.23 ± 0.10	0.24 ± 0.12	0.09 (-0.57, 0.75)
50% GCT-L (s)	0.20 ± 0.06	0.19 ± 0.04	0.20 ± 0.08	0.15 (-0.50, 0.81)
50% GCT-R (s)	0.20 ± 0.04	0.21 ± 0.05	0.19 ± 0.04	0.43 (-0.24, 1.09)
DECD-L (s)	0.69 ± 0.11	0.69 ± 0.13	0.70 ± 0.09	0.09 (-0.57, 0.74)
DECD-R (s)	0.67 ± 0.15	0.69 ± 0.13	0.66 ± 0.18	-0.19 (-0.85, 0.47)
SJ (cm)	38.5 ± 4.7	37.3 ± 5.5	40.0 ± 2.4	0.61 (0.07, 1.28)
CMJ (cm)	42.3 ± 4.9	40.6 ± 5.4	44.5 ± 2.9*	0.86 (0.17, 1.55)
RSI	1.21 ± 0.37	1.08 ± 0.31	1.39 ± 0.36*	0.90 (0.20, 1.59)
HS-MPP ($W{\cdot}kg^{-1}$)	8.48 ± 1.63	7.86 ± 1.60	9.25 ± 1.20*	0.94 (0.25, 1.64)
JS-MPP ($W{\cdot}kg^{-1}$)	9.98 ± 1.83	9.34 ± 1.92	10.85 ± 1.14*	0.92 (0.22, 1.61)

* indicates backs performed superior to forwards ($p < 0.05$).

m = meters; s = seconds; L = left; R = right; CODD = change of direction deficit; GCT = ground contact time; DECD = deceleration deficit; SJ = squat jump; CMJ = countermovement jump; RSI = reactive strength index; cm = centimeters; HS = half squat; JS = jump squat; MPP = mean propulsive power; $W{\cdot}kg^{-1}$ = watts per kilogram.

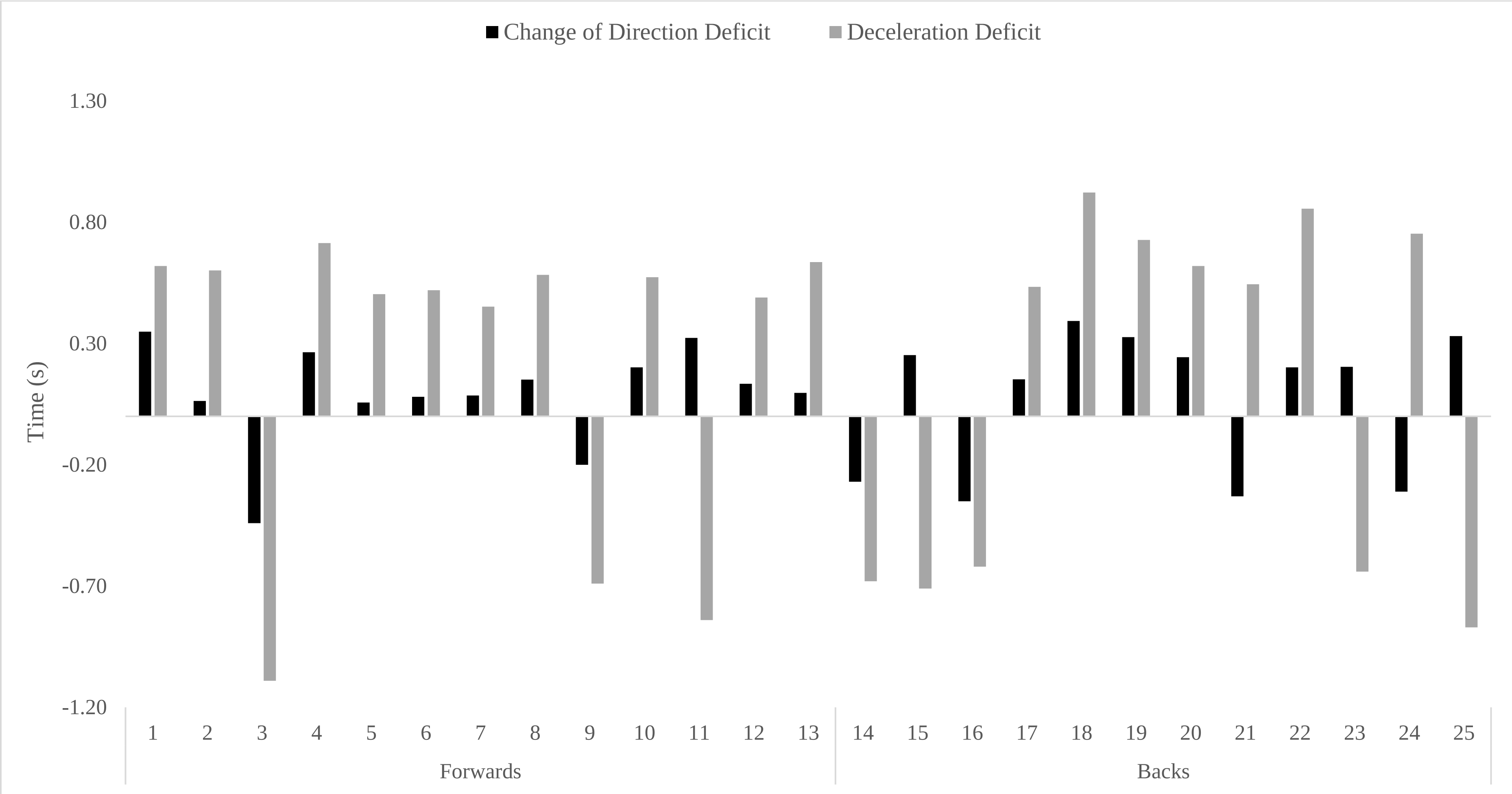

Figure 2. Individual player change of direction deficit and deceleration deficit data for the left leg (Kappa Coefficient = 0.41). N.B: above 0 indicates faster on right limb, below 0 indicates faster on left limb.

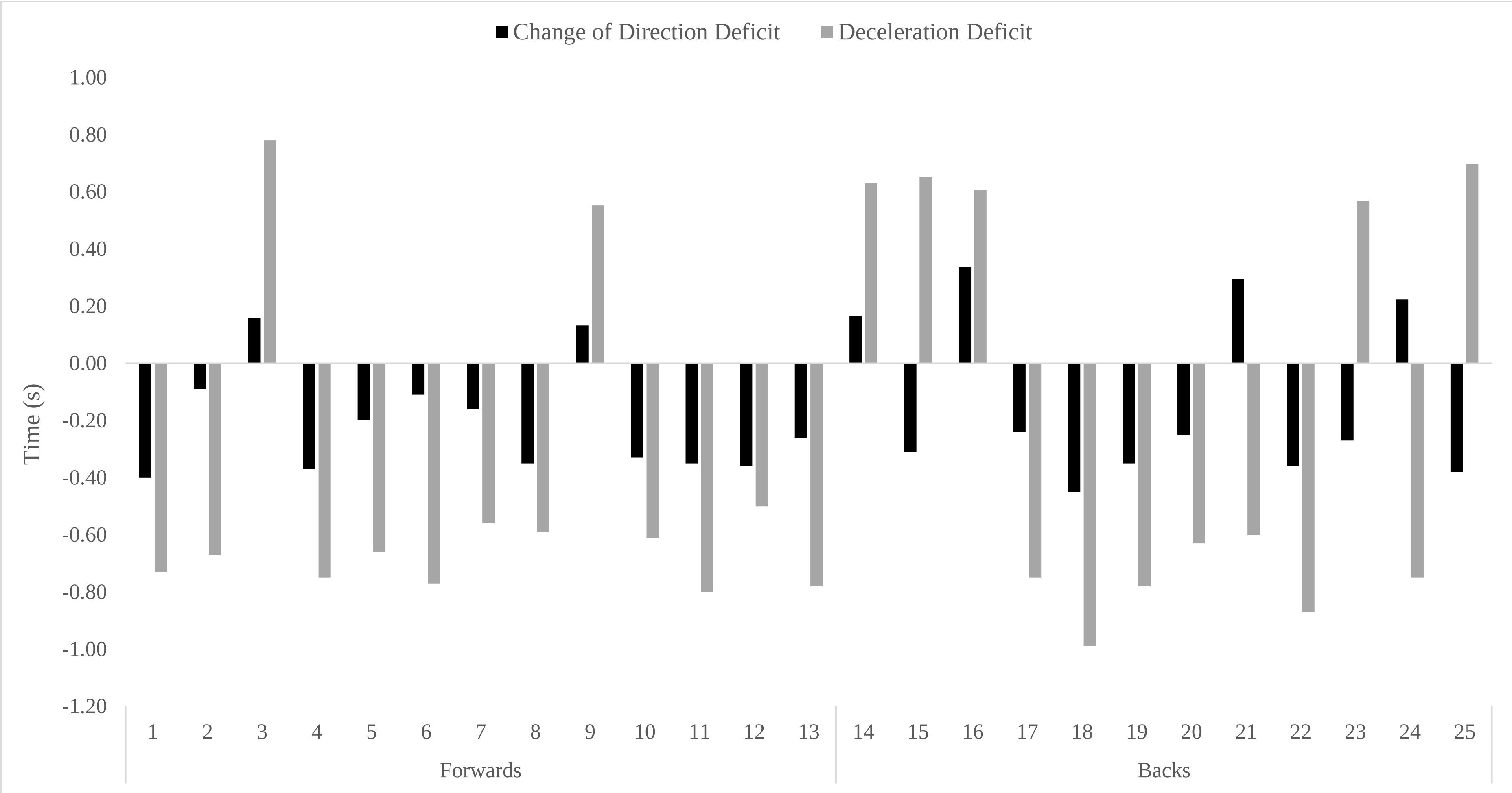

Figure 3. Individual player change of direction deficit and deceleration deficit data for the right leg (Kappa Coefficient = 0.48). N.B: above 0 indicates faster on right limb, below 0 indicates faster on left limb.

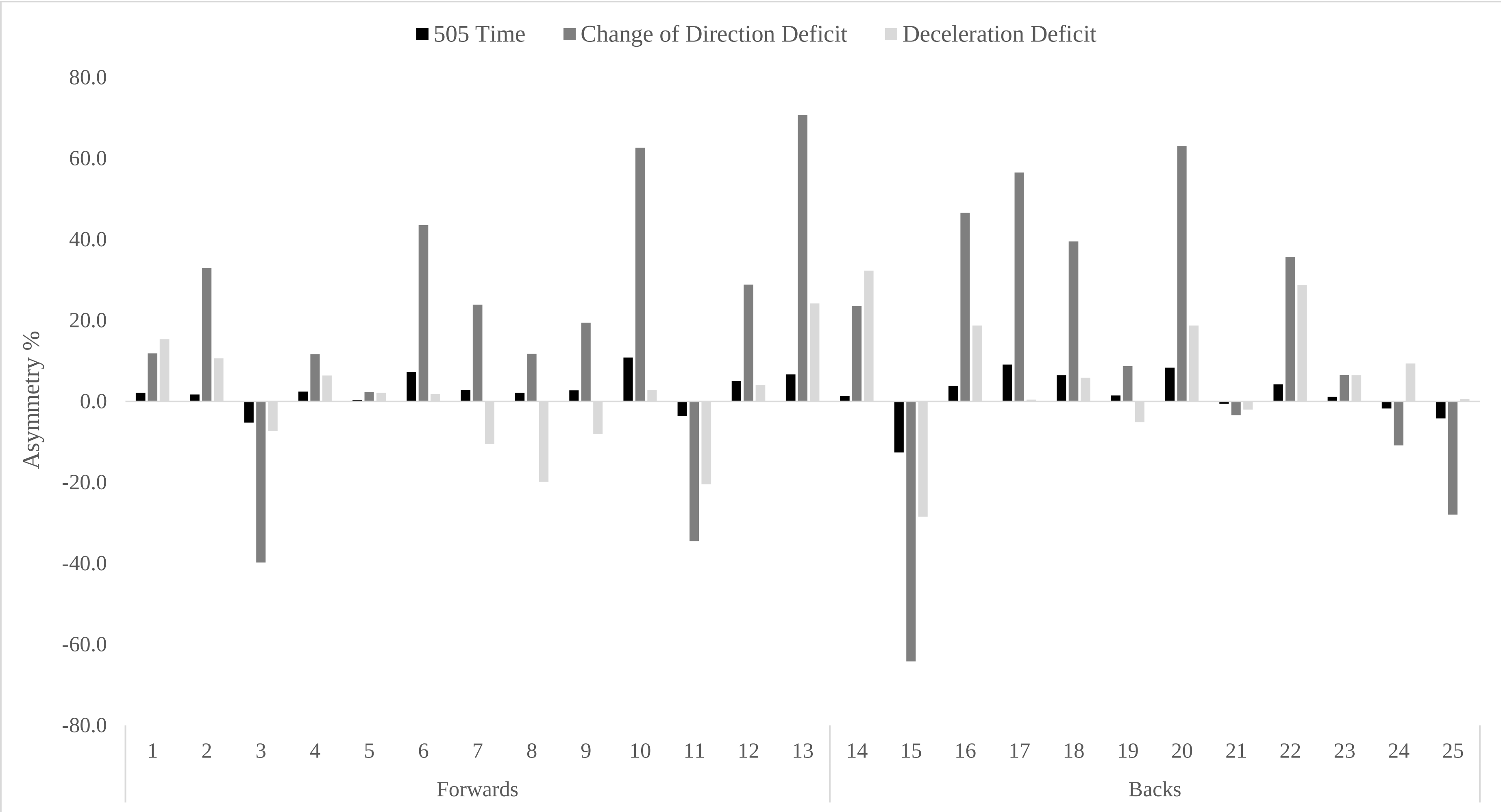

Figure 4. Individual inter-limb asymmetry data for 505 time, change of direction deficit and deceleration deficit. N.B: above 0 indicates asymmetry favours the right limb, below 0 indicates asymmetry favours left limb.

Table 3. Pearsons correlations (*r*) between jump data and 505 scores, COD-deficit (CODD) and DEC-deficit (DECD) data on both limbs.

COD Variable	SJ	CMJ	RSI	HS-MPP	JS-MPP
10-m	-0.51 (-0.75, -0.14)*	-0.51 (-0.75, -0.14)*	-0.20 (-0.55, 0.21)	-0.61 (-0.81, -0.28)*	-0.42 (-0.70, -0.03)*
15-m	-0.60 (-0.80, -0.27)*	-0.61 (-0.81, -0.28)*	-0.26 (-0.59, 0.15)	-0.68 (-0.85, -0.39)*	-0.53 (-0.76, -0.17)*
505-L	-0.58 (-0.79, -0.24)*	-0.53 (-0.76, -0.17)*	-0.38 (-0.67, 0.02)	-0.43 (-0.71, -0.04)*	-0.41 (-0.69, -0.02)*
505-R	-0.43 (-0.71, -0.04)*	-0.38 (-0.67, 0.02)	-0.29 (-0.61, 0.12)	-0.24 (-0.58, 0.17)	-0.30 (-0.62, 0.11)
CODD-L	-0.25 (-0.59, 0.16)	-0.20 (-0.55, 0.21)	-0.31 (-0.63, 0.10)	-0.03 (-0.42, 0.37)	-0.12 (-0.49, 0.29)
CODD-R	-0.14 (-0.51, 0.27)	-0.09 (-0.47, 0.32)	-0.20 (-0.55, 0.21)	0.15 (-0.26, 0.51)	-0.07 (-0.45, 0.33)
DECD-L	-0.06 (-0.44, 0.34)	-0.10 (-0.48, 0.31)	-0.23 (-0.57, 0.18)	-0.18 (-0.54, 0.23)	-0.21 (-0.56, 0.20)
DECD-R	-0.09 (-0.47, 0.32)	-0.07 (-0.45, 0.33)	-0.32 (-0.63, 0.09)	0.01 (-0.39, 0.40)	-0.15 (-0.51, 0.26)

* indicates significant correlation at $p < 0.05$.

SJ = squat jump; CMJ = countermovement jump; RSI = reactive strength index; HS = half squat; JS = jump squat; MPP = mean propulsive power; L = left; R = right.

Table 4. Spearman's correlations (ρ) between jump data and change of direction asymmetry metrics.

Asymmetry Metric	SJ	CMJ	RSI	HS-MPP	JS-MPP
505	-0.29 (-0.61, 0.12)	-0.07 (-0.45, 0.33)	-0.13 (-0.50, 0.28)	-0.28 (-0.61, 0.13)	-0.14 (-0.51, 0.27)
COD-Deficit	-0.16 (-0.52, 0.25)	-0.01 (-0.40, 0.39)	-0.08 (-0.46, 0.33)	-0.19 (-0.54, 0.22)	-0.03 (-0.42, 0.37)
DEC-Deficit	-0.06 (-0.44, 0.34)	-0.07 (-0.45, 0.33)	-0.11 (-0.48, 0.30)	0.16 (-0.25, 0.52)	-0.01 (-0.40, 0.39)

SJ = squat jump; CMJ = countermovement jump; RSI = reactive strength index; HS = half squat; JS = jump squat; MPP = mean propulsive power; L = left; R = right.