

Differences in Change of Direction Speed and Deficit Between Male and Female National Rugby Sevens Players

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¹Research Center for High Performance Sport, Catholic University of Murcia, Murcia, Spain; ²Faculty of Sport Sciences, Catholic University of Murcia, Murcia, Spain; ³Laboratory of Sport Performance Analysis, Faculty of Physical Education and Sport Sciences, University of Basque Country, Vitoria, Spain; ⁴Brazilian Rugby Confederation, São Paulo, Brazil; and ⁵NAR—Nucleus of High Performance in Sport, São Paulo, Brazil

Abstract

Freitas, TT, Alcaraz, PE, Calleja-González, J, Arruda, AFS, Guerriero, A, Kobal, R, Reis, VP, Pereira, LA, and Loturco, I. Differences in change of direction speed and deficit between male and female national rugby sevens players. *J Strength Cond Res XX(X)*: 000–000, 2019—The aims of this study were to assess the change of direction (COD) deficit in different tasks and to investigate the differences in COD ability and COD deficit between male and female rugby sevens players. Thirty-six elite rugby players from the Brazilian National senior sevens teams (18 males and 18 females) completed the following physical assessments: squat and countermovement jumps; drop jump from a 45-cm height; horizontal single and triple jumps; 40-m linear sprint; Pro-agility, L-drill, and Zig-zag COD tests; and 1 repetition maximum test in the squat exercise. The differences between male and female performances were determined using magnitude-based inferences, an independent *t* test, and effect sizes (ES). Pearson's product-moment correlations were performed to determine the relationships among the different COD velocities and COD deficits. Men demonstrated *likely* to *almost certainly* significantly higher performances than women in all speed-power assessments and COD tasks (ES ranging from 0.61 to 2.09; $p < 0.05$), with the exception of the Zig-zag drill (ES = 0.24; $p > 0.05$). Furthermore, males displayed significantly greater COD deficits in all tests and higher sprint momentum (ES ranging from 0.78 to 2.95; $p < 0.05$). *Large* significant relationships among COD velocities (r ranging from 0.71 to 0.88; $p < 0.05$) and *almost perfect* significant correlations among all COD deficits (r ranging from 0.90 to 0.95; $p < 0.05$) were obtained in both sexes. The present results indicate that male rugby players are less efficient at changing direction, relative to their maximum sprint velocity. In addition, the correlations between the different COD deficits and COD speeds suggest that elite rugby players demonstrate similar ability to change direction, independently of the angle of directional change. From a practical perspective, this implies that a more comprehensive training strategy including eccentric exercises, acceleration-deceleration drills, and directional change technique is warranted to improve the COD ability (and reduce the COD deficit) of faster and more powerful rugby sevens players.

Key Words: neuromuscular power, strength, agility, team sports, sprint

Introduction

In team sports, changing direction is one of the most frequent and determinant actions during match-play (3,17,24,43), as rapid and decisive changes in movement direction or velocity may lead to a try, a goal, or an important shift in game momentum (30). For this reason, and because athletes need to possess the necessary skills to change movement direction (i.e., change of direction [COD] ability), this quality has been a topic of interest for researchers and practitioners of many team-sport disciplines (8,19,32,34). Particularly in rugby sevens, elite players perform a considerable number of different high-intensity activities such as sprints over a wide range of distances (e.g., 10–40 m) and successive accelerations and decelerations during a game, highlighting the importance of linear and COD speed in this sport (33).

Despite the fact that, during match-play, COD mainly occurs in response to an external stimulus (e.g., ball movements,

opponents and team-mates actions, changing game situations, etc.) (4,19,42), planned COD maneuvers represent the physiological and mechanical bases that underpin the ability to accelerate and decelerate in different directions and movement planes (30). Consequently, several studies have focused on investigating the main determinants of COD performance (7,13,19,26,32,41), revealing that changing direction is a complex ability that involves a set of athletic skills, such as proper technique, straight speed, anthropometric factors, and leg muscle qualities (namely maximal strength, reactive strength, and power) (6,35). Accordingly, Condello et al. (11) observed a significant correlation ($r = 0.75$) between straight sprint and a 60° COD task in young rugby players of 6 different age categories (from U9 to U19), suggesting that linear speed may be a good predictor of COD ability in these groups. Similar results were obtained with adult rugby players performing a 20-m straight sprint test and the 505, modified 505, and L tests (19). Furthermore, Delaney et al. (13) reported that linear speed together with lateral jump ability and relative lower-body strength power are potentially the main factors contributing to COD performance (505 test) in professional rugby players. By

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contrast, studies conducted in other team sports (basketball and Australian rules football) found only low-to-moderate correlations between linear sprint and COD ability (determined by test completion time or speed) (7,41). These discrepancies in the literature raise the question as to whether, conceptually, strength and conditioning coaches have been using the most appropriate methods to measure and develop COD speed.

As such, a new approach has emerged for assessing COD ability, proposed as a more suitable way to evaluate this specific quality in team sports (26,31,32). The “COD deficit” corresponds to the additional time required to complete a directional change when compared with the time needed to cover an equivalent distance in a linear sprint (31). This promising concept allows for evaluation of COD as a separate quality (isolating the acceleration capability of the athlete) and has started to be implemented in recent investigations with different athletic populations (16,26,31,32,40). For example, Loturco et al. (26) identified that faster and more powerful soccer players presented an inferior capacity to effectively change direction when analyzing the COD deficit data. In another study performed with Olympic handball players, the COD deficit was more strongly associated with speed-power outcomes than the Zig-zag COD test total time (32). Moreover, Dos Santos et al. (16) concluded that the COD deficit was a more accurate method to assess unilateral asymmetries in young netball players than COD task completion times. Together, these findings encourage the use of the COD deficit as a supplementary and appropriate measure of COD performance.

An important aspect to consider when examining the multifaceted aspects of COD maneuvers is that there is no “gold-standard test” to assess these quality attributes (6,42). This implies that it is not possible to determine universal predictors of COD performance, as the outcome will always be task-specific. In fact, a previous study found that the COD deficit seems to be dependent on the test performed in rugby union players (18). However, to date, no studies have investigated the COD deficit from different COD drills in rugby sevens players, specifically. In addition, it has been shown that male athletes achieve better performances in COD tests than female athletes (9,38); nonetheless, few studies have actually investigated (and compared) the COD deficit in different sexes (32,40). To the best of our knowledge, in rugby, no previous studies have directly compared the COD ability and COD deficit of male and female athletes (particularly with a sample of National Olympic athletes). Therefore, the aims of this study were to: (a) investigate the differences in COD ability and several speed- and power-related measurements between male and female national rugby sevens players; (b) examine the differences in COD deficits; and (c) analyze the relationships between COD deficit and COD speed in different COD tasks in both sexes. Based on previous research, we hypothesized that male athletes would outperform female players in all speed- and power-related measurements, while presenting higher COD deficits in the different tasks assessed.

Methods

Experimental Approach to the Problem

A cross-sectional comparative study design was used, aiming to assess the COD deficit in different COD tasks in elite male and female rugby sevens players. Owing to the constant training and assessment in our facilities, all athletes were familiarized with the testing procedures.

Male and female players completed the physical assessments in a single testing session, on separate occasions, 1 week apart. On testing days, the assessments were performed between 9:00 and 13:00, in the following order: squat jump and countermovement jump (SJ and CMJ); drop jump from a 45-cm height (DJ45); horizontal single jump (HJ) and triple jump (TJ); 40-m linear sprint; Pro-agility COD test, L-drill COD test, and Zig-zag COD test; and 1 repetition maximum (1RM) test in the squat exercise. Before the tests, athletes performed a standardized warm-up protocol including general (i.e., running at a moderate pace for 10 minutes followed by active lower-limb stretching for 3 minutes) and specific exercises (i.e., submaximal attempts at each tested exercise). Verbal encouragement was provided for the athletes during all testing sessions.

Subjects

Thirty-six elite rugby players (males: $n = 18$; age: 24.6 ± 2.8 years (all male subjects were 18 years or older); body mass: 86.7 ± 9.6 kg; height: 186.2 ± 5.0 cm; females: $n = 18$; age: 22.6 ± 4.6 years (all female subjects were 18 years or older); body mass: 64.1 ± 7.2 kg; height: 166.7 ± 6.1 cm) from the Brazilian National Team participated in this study. This elite sample included 5 players (1 man and 4 women) who participated in the rugby sevens Olympic tournament at Rio-2016 and 10 female players who participated in the most recent Rugby Sevens World Cup (San Francisco, 2018), attesting to their high level of competitiveness. Rugby players were tested in the final phase of the preparation for important international competitions. Subject characteristics are expressed mean \pm SD. The study was approved by the Anhanguera-Bandeirante University 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 jump ability was assessed using the SJ, CMJ, and DJ45. In the SJ, a static position with a 90° knee flexion angle was maintained for 2 seconds before a jump attempt without any preparatory movement. In the CMJ, players were instructed to perform a downward movement followed by complete explosive extension of the lower limbs. The depth of the countermovement was self-determined to avoid changes in the jumping coordination pattern. In the DJ45, subjects were instructed to step-off the box, one foot at a time, to touch the ground with knees extended and ankles in plantar flexion (so that the toes made contact with the floor first) and to jump “as high and as fast as possible” to ensure the validity of the test (28). All jumps were executed with the hands on the hips. Five attempts at each jump were performed interspersed by 15-second intervals. Jump height, in centimeter, of the CMJ and SJ were determined based on flight time, using a previously validated contact mat (Elite Jump; S2 Sports, São Paulo, Brazil) (27). The highest jump was used for data analysis purposes in the SJ and CMJ. For the DJ45, the best reactive strength index (RSI) was taken from the jump height (in millimeter) divided by the ground contact time (in millisecond) before the take-off.

Horizontal Jumps. Athletes performed the HJ and TJ starting from a standing position, with knees bent. Arm swing was allowed to provide maximal forward drive. In the HJ, athletes jumped as far as possible with both legs. For the TJ, athletes performed 3 maximal horizontal bilateral jumps in sequence. The

jump distance, in meter, was determined using a metric tape measure (Lufkin, L716MAGCME; Apex Tool Group, Sparks, MD), from the take-off line to the nearest point of landing contact (i.e., back of the heels). Each athlete executed 3 attempts at each jump, interspersed by 30-second intervals, and the trial with the longest distance was retained for the analyses.

Linear Sprint Velocity. Five pairs of photocells with a dual-beam light gate system (Smart Speed; Fusion Equipment, Brisbane, Australia) were positioned at the starting line and at distances of 10, 20, 30, and 40 m along the sprinting course. Athletes sprinted twice, from a standing position 0.3 m behind the starting line. To avoid weather influences, the sprint tests were performed on an indoor running track. A 3-minute rest interval was allowed between the 2 attempts, and the fastest time was considered for the analyses. Sprint momentum ($\text{kg}\cdot\text{ms}^{-1}$) was obtained by multiplying the athlete's body mass by the respective velocity during the linear sprint.

Change of Direction Ability. Players performed the following 3 COD tasks: the Pro-agility, L-drill, and Zig-zag tests. In the Pro-agility test (5-10-5), subjects started in a standing position over the starting line, facing one of the photocells. At the instructor's signal, athletes turned and sprinted 5 m, touching the line, then turned 180°, and ran 10 m to touch the other line. Finally, they sprinted 5 m toward the finishing line, covering a total distance of 20 m (Figure 1) (37). Athletes performed 2 attempts starting to the right side and 2 to the left. The fastest time of the 4 attempts was considered for analysis.

The Zig-zag COD test consisted of four 5-m sections (total 20 m of linear distance) marked with cones set at 100° angles (Figure 2) (25), requiring the athletes to decelerate and accelerate as fast as possible around each cone. Two maximal attempts were performed with a 5-minute rest interval between them. Starting from a standing position with the front foot placed 0.3 m behind the first pair of timing gates (Smart Speed; Fusion Equipment) (i.e., starting line), athletes were encouraged to complete the test as quickly as possible by crossing the second pair of timing gates, placed over the finishing line. The fastest time from the 2 attempts was retained for further analyses.

In the L-drill, subjects started in a standing position and were required to sprint forward 5 m, touch the line, and sprint back to the starting line. Next, they performed a 180° directional change and sprinted to the first cone, cut 90°, and circled the second cone. Finally, players performed another 90° cut before completing the 30-m test by sprinting through the photocells placed on the finishing line (Figure 3) (37). Athletes performed 2 attempts starting to the right side and 2 to the left. The fastest time of the 4 attempts was considered for analysis.

To evaluate each athlete's ability to use their linear speed during a specific COD task, an adapted COD deficit calculation

was used, as described elsewhere (31,32). Thus, each COD deficit was calculated based on the difference between linear sprint and COD velocities (obtained by dividing test distance by test completion time) of tasks of equal distance, as follows: (a) Pro-agility: 20-m velocity—Pro-agility test velocity; (b) Zig-zag: 20-m velocity—Zig-zag test velocity; and (c) L-drill: 30-m velocity—L-drill velocity.

One-Repetition Maximum Test in the Squat Exercise. The 1RM test was performed using an Olympic barbell. The testing protocol was adapted from the procedures proposed by Brown and Weir (5). Before the test, athletes performed 3 specific squat warm-up sets. In the first set, subjects performed 4 repetitions with 50% of the estimated 1RM (i.e., based on prior assessments); in the second set, they performed 3 repetitions with 60% of the estimated 1RM; and in the third set, they performed 2 repetitions with 70% of the estimated 1RM. A 3-minute resting interval was allowed between sets. Three minutes after the warm-up, subjects were allowed up to 5 attempts ($\approx 80, 90, 95\%$, and [1–2 repetitions] $>95\%$ of the estimated 1RM) to obtain the 1RM load (e.g., maximum weight that could be lifted once using the proper technique), with a 3-minute interval between attempts. To account for differences in the body mass of the athletes, values were normalized by dividing the 1RM load value by the athlete's body mass.

Statistical Analyses

Data are presented as means and SDs. Data normality was confirmed with the Shapiro-Wilk test using the SPSS software package, version 22.0. (SPSS, Inc., Chicago, IL, USA). The differences between male and female performances in all variables were analyzed using the magnitude-based inference (2) and the

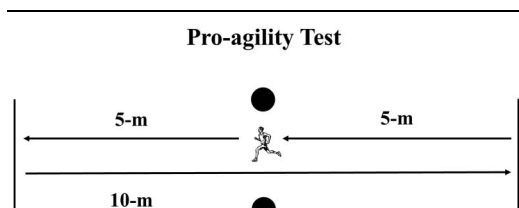


Figure 1. Schematic presentation of the Pro-agility test. Circles represent the position of the photocells.

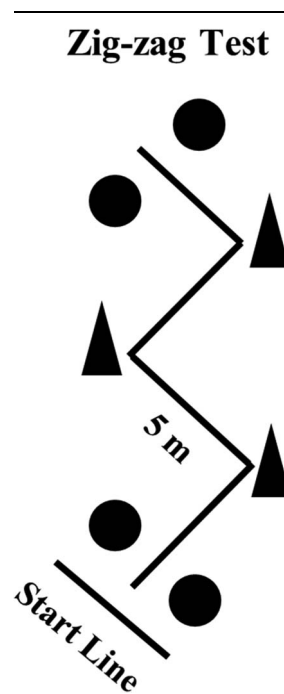


Figure 2. Schematic presentation of the Zig-zag test. Circles represent the position of the photocells.

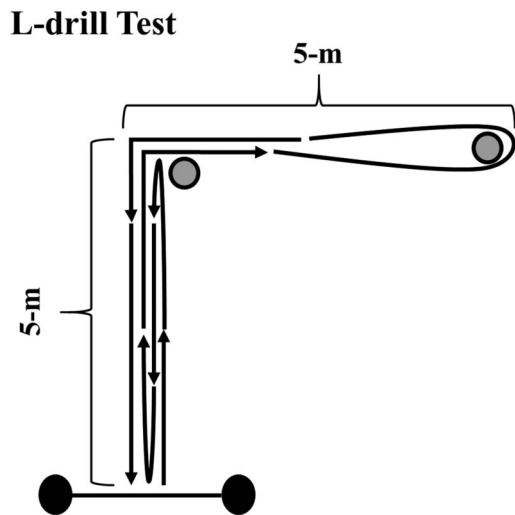


Figure 3. Schematic presentation of the L-drill test. Black circles represent the position of the photocells and gray circles the position of the cones.

independent *t* test. The quantitative chances of finding differences between the variables tested were assessed qualitatively as follows: <1%, almost certainly not; 1–5%, very unlikely; 5–25%, unlikely; 25–75%, possibly; 75–95%, likely; 95–99%, very likely; and >99%, almost certainly. If the chances of having better and poorer results were both >5%, the true difference was deemed unclear. The magnitudes of the differences for the comparisons in all variables were analyzed using the Cohen’s *d* effect size (ES) (10,21). The magnitudes of the ES were qualitatively interpreted using the following thresholds: <0.2, trivial; 0.2–0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; 2.0–4.0, very large; and >4.0, almost perfect (21). A Pearson product-moment test was performed to determine the correlations among the performances in the 3 different COD tests and among the COD deficits. The correlations were interpreted using the following criteria proposed by Hopkins et al. (21): <0.1, trivial; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; and >0.9 almost perfect. The significance level for the *t* test and for the correlation analysis was set as *p* < 0.05. Intra-class correlation coefficients and coefficients of variation were calculated for every test performed in this study and were all >0.90 and <5%, respectively, for male and female athletes. Finally, the typical error of measurement (TE%) was also

calculated for all physical tests. The TE varied between 2.2 and 10.3% and between 2.8 and 10.6% for male and female players, respectively.

Results

Figure 4 shows the comparisons of the VJ and HJ between male and female rugby players. Male athletes showed *almost certainly* and significantly better performances than female players in all jump tests (ES = 1.98, 1.47, 1.80, and 1.88, for SJ, CMJ, HJ, and TJ, respectively; *p* < 0.05). For the DJ45, *likely* and significant differences were observed in the RSI when comparing male and female players (males: 1.30 ± 0.47 mm·ms⁻¹; females: 1.03 ± 0.41 mm·ms⁻¹; ES: 0.61; *p* < 0.05). Concerning maximal dynamic strength, male players demonstrated a *very likely* and significantly higher 1RM load in the squat exercise than female athletes (males: 1.78 ± 0.26 kg·kg⁻¹; females: 1.50 ± 0.21 kg·kg⁻¹; ES = 1.15; *p* < 0.05).

Figure 5 depicts the comparisons of the linear sprint velocity and sprint momentum between male and female athletes. Male players demonstrated *almost certainly* and significantly higher performances than female athletes in the sprint velocity, and *almost certainly* and significantly greater momentum in all distances tested (ES = 2.51, 2.06, 1.64, and 1.75 for velocity, and ES = 2.95, 2.89, 2.87, and 2.89 for sprint momentum in 10, 20, 30, and 40 m, respectively; *p* < 0.05).

Figure 6 compares the COD velocity and COD deficit of male and female players in the 3 different tests performed. Male athletes demonstrated *almost certainly* and significantly better performances than female players in the Pro-agility and L-drill tests (ES = 2.09 and 1.53, respectively; *p* < 0.05). The comparison of the Zig-zag velocity between male and female players was rated as *unclear* and nonsignificant (ES = 0.24; *p* > 0.05). In relation to the COD deficit, *likely* to *almost certainly* and significantly higher deficits were observed for male players when compared with female players (ES = 0.78, 1.72, and 1.00 for the deficits calculated from Pro-agility, Zig-zag, and L-drill tests, respectively; *p* < 0.05).

The coefficients of correlation obtained among the different COD test velocities and deficits are shown in Table 1. All correlations were statistically significant (*p* < 0.05). The Pro-agility velocity was *largely* associated with the L-drill and Zig-zag in both sexes. Likewise, the L-drill and Zig-zag velocities were *largely* associated in male and female athletes. Regarding the COD deficits, all outcomes were *almost perfectly* correlated in males and females.

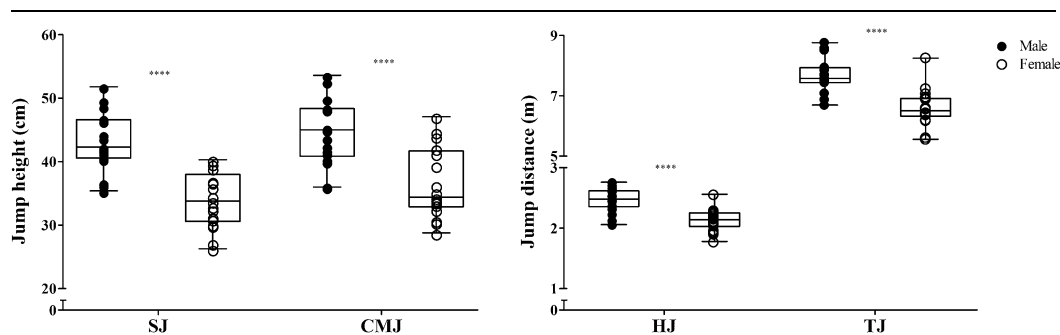


Figure 4. Comparisons of the vertical and horizontal jumps between male and female rugby players. The figure demonstrates the spread from minimum to maximum with the line of the box-and-whisker plot at the mean along with individual data points to show the full spread of data. ****Almost certainly different and *p* < 0.05. SJ = squat jump; CMJ = countermovement jump; HJ = horizontal jump; TJ = triple jump.

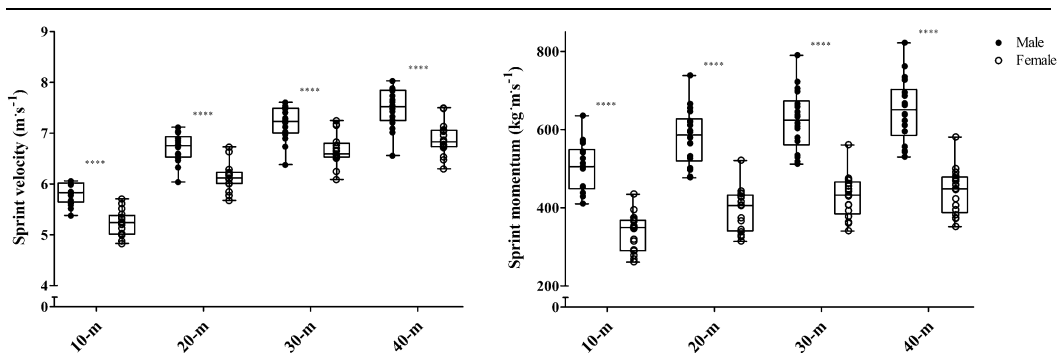


Figure 5. Comparisons of the sprint velocity and momentum in the different distances tested between male and female rugby players. The figure demonstrates the spread from minimum to maximum with the line of the box-and-whisker plot at the mean along with individual data points to show the full spread of data. ****Almost certainly different and $p < 0.05$.

Discussion

The main purposes of this study were to: (a) investigate the differences in COD ability and several speed- and power-related measurements between elite-level male and female rugby sevens players; (b) examine the differences in COD deficit between sexes; and (c) assess the COD deficit and its relationships with COD velocity in different COD tasks. In general, the performance test values reported here were similar to those obtained in similar studies involving female (1) and male team-sport athletes (19,20). As expected, men outperformed women in all speed-power assessments (i.e., linear sprint, VJ and HJ, DJ45, and squat 1RM) and COD tasks, with the exception of the Zig-zag test, which is in accordance with previous findings (9,32,40). In addition, men presented *very likely* higher sprint momentum than women and greater COD deficits in all COD maneuvers. Although this may seem surprising at first glance, different studies performed with soccer and handball players reported similar conclusions, revealing that faster and more powerful athletes present higher levels of COD deficit than their slower and less powerful peers (26,32).

Remarkably, the Zig-zag test completion time did not differ between male and female athletes, which outlines the necessity for male players to perform more specific drills that mimic this COD maneuver during the training sessions. It is worth noting that the rugby sevens game is played on a rugby union field with only 14 players (thus resulting in more space per player) and that linear

sprinting and “smoother” directional changes (less sharp angles) are frequent and of greater relevance in this team-sport modality (33). A possible rationale as to why unclear differences were found between sexes in the Zig-zag task, but not when sharper COD was performed (i.e., Pro-agility and L-drill tests), may be related to the fact that men had greater acceleration rates over very-short distances (as seen by the *very large* differences obtained in the linear 10-m sprint). Therefore, it is plausible to assume that in maneuvers with sharper directional changes, in which deceleration and (maximum) acceleration play a pivotal role (15), the differences between sexes would be bigger, even if men present greater COD deficits. It is important to clarify that the COD deficit is an indicator of the athlete’s efficiency to change direction (relative to his or her maximum sprint velocity), but not that he or she is slower during the task (in absolute terms).

Regarding the COD deficits, sprint momentum is a key outcome that potentially explains why men displayed higher values than women. Faster and heavier athletes have been found to obtain higher sprint momentum (22,29), hence, inertia. This is a crucial aspect that should not be overlooked when investigating COD ability. An athlete with greater sprint momentum and approach velocity in a COD maneuver will necessarily need to apply higher braking forces through longer ground contact times (15). As a result, COD speed will decrease (36) and more pronounced eccentric muscle actions will necessarily be used (15,23) to efficiently reverse momentum and, consequently, change direction. Jones et al. (23) reported that athletes with greater eccentric

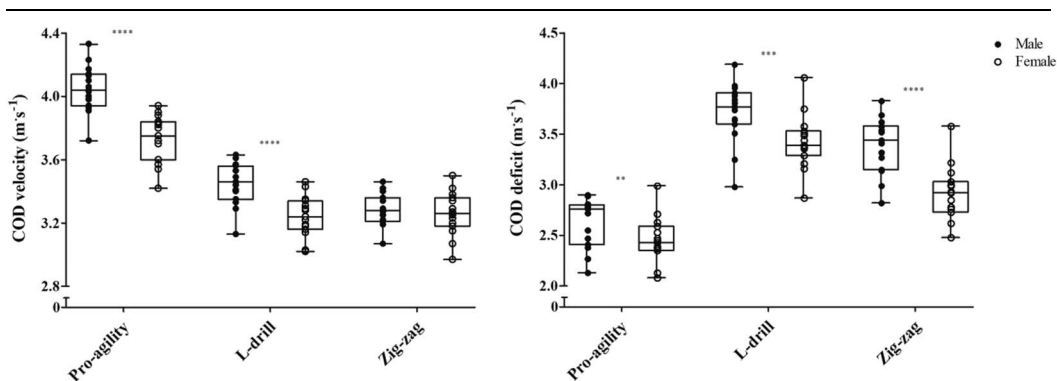


Figure 6. Comparisons of the COD velocity and COD deficit in the 3 different tests performed between male and female rugby players. The figure demonstrates the spread from minimum to maximum with the line of the box-and-whisker plot at the mean along with individual data points to show the full spread of data. **Likely different and $p < 0.05$; ***very likely different and $p < 0.05$; ****almost certainly different and $p < 0.05$. COD = change of direction.

Table 1
Correlation coefficients in velocity and deficit scores among the different change of direction (COD) tests performed in male and female rugby players.

	Male		Female	
	L-drill	Zig-zag	L-drill	Zig-zag
COD velocity				
Pro-agility	0.71*	0.80*	0.75*	0.71*
L-drill	—	0.84*	—	0.88*
COD deficit				
Pro-agility	0.91*	0.95*	0.90*	0.92*
L-drill	—	0.95*	—	0.94*

* $p < 0.05$.

strength were able to better decelerate during a 180° turn and tolerate faster approach velocities during the COD maneuver, which raises important questions regarding the development of future training strategies of elite rugby players. From an applied perspective, it appears that practitioners are overemphasizing linear sprint training and top speed development when, in fact, more attention should be paid to specific COD training, with special emphasis on eccentric strength (12) and directional change technique (14,15). In this regard, de Hoyo et al. (12), applying a 10-week eccentric overload training program in football players, and Dempsey et al. (14), following a 6-week COD technique-oriented intervention with a sample of team-sport athletes, reported meaningful improvements in COD mechanics, suggesting that training strategies focused on increasing eccentric strength or teaching proper technique may be useful to reduce the COD deficit in faster and more powerful athletes.

This study is the first to use the COD deficit calculation in rugby players to assess their ability to effectively change direction in a variety of preplanned COD maneuvers. Of note, all the COD deficit outcomes were *almost perfectly* correlated and all the COD speed velocities were *very largely* correlated (Table 1), indicating that higher deficits and performances in the Pro-agility test were associated with greater deficits and performances in the L-drill and Zig-zag tests. Despite previous evidence indicating that COD ability is task- and angle-specific (6,15), the *almost perfect* correlations reported for COD deficits suggest that the athletic population studied herein is equally inefficient at changing direction in drills with quite dissimilar angles of directional change. These results have important implications, as they highlight that Olympic level rugby players are not proficient enough to perform tasks involving sequential accelerations and decelerations, which seems to be independent of the movement pattern (i.e., task-specificity). Therefore, it can be assumed that the ability to efficiently change direction with different angles and velocities is underpinned by similar neuromechanical factors such as the capability to decelerate and tolerate high eccentric loads (12,23), speed-power qualities (32), and task-specific COD technique (15). Based on our data, training programs focused on developing the aforementioned aspects would equally benefit the execution of different COD maneuvers, potentially improving the athletes' ability to execute rapid directional changes in different conditions, by reducing COD deficits in preplanned tasks.

The limitations of this study should be addressed. First, the cross-sectional design used does not allow for determination of the influence of different training interventions on variables such as COD technique, eccentric strength, or speed-power qualities. Second, as previously mentioned, during match-play, COD

mainly occurs in response to an external stimulus, while in this study only planned COD maneuvers were assessed. However, it is important to keep in mind that such tasks allow for the study of the physiological and mechanical bases that underpin the ability to accelerate and decelerate in different directions. Future research should replicate a similar study using different athletic populations, specifically with players from team-sport modalities, in which sprint momentum would not differ greatly between sexes, as occurs with rugby. Moreover, it would be interesting to examine the reliability of the COD deficit in elite players, particularly since this has recently been questioned in elite youth academy soccer players (39). Studies identifying the biomechanical parameters associated with more efficient COD performances (i.e., lower COD deficits) and examining the movement strategies used by "top performers" would also prove valuable. Finally, experimental interventions must be considered to analyze whether multifaceted training programs including components of eccentric exercises, balance, acceleration-deceleration drills, resisted sprints, and specific (loaded and unloaded) COD maneuvers are capable of reducing the COD deficit and improving the COD performance of faster and more powerful team-sport athletes.

In conclusion, the results of this investigation indicate that elite male rugby players displayed superior performance outcomes in all speed-power qualities and COD tasks, with the exception of the Zig-zag test, when compared with female athletes. Moreover, men obtained greater COD deficits, independently of the exercise, most likely due to their higher sprint momentum. Thereby, it appears that male rugby sevens players are less efficient at changing direction, relative to their maximum sprint velocity, in comparison with women. This study is the first to investigate and report *almost perfect* correlations between COD deficits calculated for the Pro-agility, L-drill, and Zig-zag tests, in both male and female rugby sevens players. This novel finding seems to suggest that a poor ability to tolerate higher approach velocities before a given COD (i.e., a higher COD deficit) is associated with greater COD deficits in other maneuvers with different numbers or angles of directional changes, in elite rugby sevens players.

Practical Applications

This study has important implications for practice and future research. The greater COD deficits obtained in all tests by the faster and more powerful male players suggest that these athletes have an inferior ability to efficiently change direction and cope with faster entry velocities in COD maneuvers, independently of the angle of directional change. As a consequence, to increase COD-related performance, the training focus should be redirected from a speed-power, linear sprint, and maximum velocity development perspective toward a more COD-specific approach. Drills emphasizing COD mechanics, proper deceleration and acceleration techniques, maintenance of velocity during game-specific COD tasks, and eccentric overload of the main muscles involved could be potential strategies to be used by sport scientists and strength and conditioning coaches. The *almost perfect* correlations between COD deficits of different tests in male and female rugby players indicate that improving the abovementioned qualities would conceivably have a positive effect on COD performance in different conditions (namely COD angles).

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