The Bilateral Deficit during Jumping Tasks: Relationship with Speed and Change of Direction Speed Performance

ABSTRACT

Research to date has investigated the phenomenon of the bilateral deficit (BLD); however, limited research exists on its association with measures of athletic performance. The purpose of the present study was to investigate the magnitude of the BLD and examine its relationship with linear speed and change of direction speed (CODS) performance. Eighteen physically active and healthy university students performed double and single leg countermovement jumps (CMJ), drop jumps (DJ) and standing broad jumps (SBJ), to calculate the BLD across jump tasks. Subjects also performed 10m and 30m sprints and a 505 CODS test, which were correlated with all BLD metrics. Results showed varying levels of BLD across CMJ metrics (jump height, peak force, eccentric impulse, concentric impulse, peak power), DJ metrics (ground contact time, flight time), and the SBJ (distance). However, a bilateral facilitation (BLF) was shown for jump height and reactive strength index (RSI) during the DJ test. The main findings of the present study were that: 1) a larger BLD in CMJ jump height related to a faster 505 change of direction (COD) (left leg) (r = -0.48; p = 0.04), 505 COD (right leg) (r = -0.53; p = 0.02) and COD deficit (right leg) (r = -0.59; p = 0.01), 2) a larger BLD in CMJ concentric impulse related to faster 505 COD (left leg) (r = -0.51; p = 0.03), 505 COD (right leg) (r = -0.64, p = 0.01) and COD deficit (right leg) (r = -0.60; p = 0.01), 3) a larger BLD in DJ flight time related to a faster 505 COD (left leg) (r = -0.48; p = 0.04). These results suggest that a larger BLD is associated with faster CODS performance, but not linear speed. This highlights the individual nature of the BLD and may support the notion of developing movement competency on one limb for enhanced CODS performance.

Key Words: Fitness testing; sprinting; training implications

INTRODUCTION

The bilateral deficit (BLD) phenomenon refers to the observation that force production during a maximal bilateral contraction tends to be lower than the sum of total force produced by the left and right limbs combined (19). Thus, a true examination of the BLD is only possible when comparable bilateral and unilateral tasks have been completed (e.g., bilateral and unilateral countermovement jumps [CMJ]). The presence of the BLD has been demonstrated during isometric (5,6,18,24,28,29), isokinetic (8,12,13,19,24,40), explosive (4,9,10,30,31,33,39,40) and sport-related motor tasks (7). However, speculation still exists as to the underlying mechanisms responsible for this phenomenon. Several theories have been proposed to explain the existence of the BLD, including changes in motor unit recruitment (13,20,29), the force-velocity relationship (4,15), neural mechanisms (18), limb dominance (18), training preference (i.e., bilateral over unilateral movements and vice versa) (18,34) and the ability to counter-balance and support movement (24,35). Therefore, it may be plausible to suggest that multiple mechanisms contribute to the prevalence of the BLD.

A further factor for consideration when addressing the BLD is task-specificity. Although this notion has not been addressed in a direct comparison, research appears to indicate that this phenomenon appears more frequently in dynamic contractions (e.g., jumping), than isometric contractions (e.g., knee extension) (36). Whilst the interaction of multiple joints during dynamic movements may play a role in the occurrence of the BLD (4), it is important to recognize that such modes of testing and training (e.g., jumping) are more akin to the methods employed by strength and conditioning coaches. Thus, an in-depth analysis of the BLD during multiple jumping-based tasks would provide novel information for coaches.

The association between BLD and athletic performance is largely unexplored. Bračič et al. (7) examined the relationships between the BLD during the CMJ and sprint start performance in elite level sprinters. Results showed that a smaller BLD was correlated with higher peak force production (r = -0.63; $p < 0.01$) and higher total impulse on the blocks (r = -0.55; $p < 0.01$), indicating that a lower BLD may be favorable for sprint start performance. Based on the work of Bračič et al. (7), it could be surmised that a smaller BLD may be more favourable for athletes performing in bilateral sports (that require the use of two limbs at the same time, such as rowing) or performing bilateral actions (e.g., jumping). However, this study only relates to sprint start performance as opposed to a performance outcome, such as total sprint time. In contrast, team-sport athletes frequently perform unilateral actions (e.g., sprinting, change of direction, kicking); thus, it could be speculated that they may potentially benefit from having a larger BLD, to ensure increased competence when performing unilateral actions. However, and to the authors' knowledge, relating the BLD to other measures of athletic performance (such as CODS) does not exist to date. Delineating the extent of this relationship would also provide coaches and athletes with useful insight into the potential efficacy of unilateral or bilateral training and the associated benefits for a given task.

Due to the paucity of research in this area, the aims of the present study were twofold: 1) to quantify the BLD across multiple jumping tasks and, 2) determine the relationship between the BLD and speed and CODS performance. Given previous research, it was hypothesized that the magnitude of BLD would vary according to the selected jump test. In addition, although research to date on the relationship between the BLD and physical performance is scarce, it was hypothesized that significant relationships would be present.

METHODOLOGY

Experimental Approach to the Problem

The present study used a cross sectional design where subjects performed bilateral and unilateral countermovement jumps (CMJ), drop jumps (DJ), standing broad jumps (SBJ), 10, 30m and 505 CODS tests. During test familiarization, subjects were provided with the relevant test instructions and time to practice each test an unlimited number of times to ensure they were familiar with all procedures. This was both monitored by an accredited strength and conditioning coach and verbally discussed with each participant to ensure both parties were satisfied with requirements before data collection. Data was then captured across two separate testing days (separated by 72 hours) to ensure maximal performance was provided on each test. All jump tests were conducted in a randomized order during test session one. Test session two involved the completion of speed and CODS tests, again in a randomized test order. Subjects were asked to refrain from strenuous exercise 48 hours before each testing session and adhere to their usual diet. In addition, both test sessions took place at the same time of day between the hours of 13:00-16:00. The best trial was used for subsequent analysis in all tests and for the calculation of the BLD across jump tests (specified as the trial with the greatest jump height during the CMJ and DJ and greatest distance during the SBJ). Relationships between the BLD scores and each sport-related test were then subsequently determined.

Subjects

A sample of 18 recreationally trained and physically active male students (age: 25.5 ± 3.8 yr; height: 1.77 ± 0.07 m; body mass: 75.3 ± 10.4 kg) were recruited for this study. In order to be eligible for participation, subjects were required to be injury free at the time of testing and have at least two years resistance and plyometric training experience to reduce the risk of task unfamiliarity. Written informed consent was obtained prior to commencement and subjects were required to complete a health screen questionnaire. This study was approved by the London Sport Institute research and ethics committee at Middlesex University, London, UK.

Procedures

Before each session, subjects performed a dynamic warmup. This consisted of a 3-minute jog in an indoor athletics track, followed by dynamic stretches to the lower body (2 x 10 on body weight squats, forward and lateral lunges, and inchworms). Activation and mobilisation exercises followed (2 x 10 on glute bridges, scapula push ups and thoracic spine rotations) and three practice trials for each test at approximately 60, 80 and 100% perceived maximal effort. Three minutes recovery was provided between the last warm-up trial and data collection. Two repetitions of each test were performed, with a 60-second recovery between jumps and two minutes between the sprint and CODS tests.

Bilateral and Unilateral Countermovement Jump (CMJ). Subjects performed CMJ on a single force plate (PASPORT force plate, PASCO Scientific, California, USA) that operated at 1000 Hz. To ensure the collection of reliable data, the force plate was zeroed before each athlete stood on it. Following this, subjects were asked to stand motionless for a period of two seconds before performing the jumps. This enabled calculation of bodyweight to be obtained when analysing the data, using a custom-built CMJ spreadsheet developed by Chavda et al. (11). This was also used to quantify the jumper's bodyweight by averaging the motionless period, and allowed for the first meaningful change in force to be established, which was calculated as ± 5 standard deviations (SD) of bodyweight, in line with previous suggestions (2,11). During the CMJ, subjects were instructed to "stand tall, look forward and place hands on hips" to ensure that arm swing did not contribute to jump performance. Subjects then squatted down to a self-selected position before jumping, maintaining full lower-body extension during the flight phase of the jump. Any deviation from these instructions resulted in a void trial and the jump was retaken after 60-seconds. Recorded metrics included jump height (determined from the calculation: velocity at take-off divided by [2*9.81], where 9.81 represents gravitational force), peak force (the largest force generated before take-off), eccentric impulse (mean net force exerted multiplied by the time taken to produce it during the eccentric braking phase of the jump), concentric impulse (mean net force multiplied by the time taken to produce it during the concentric propulsion phase of the jump) and peak power (net force multiplied by velocity to obtain the maximum value).

Bilateral and Unilateral Drop Jump (DJ). The OptoJump optical measurement system (Microgate, Bolzano, Italy) was employed to assess DJ performance. In order to ensure all jump testing took place at the same time, this equipment was used owing to only a single force platform being available. Each jump was performed from a 0.3 m drop height during both unilateral and bilateral protocols. Subjects received specific instructions to “stand tall, look forward and place hands on hips”. They were also given a verbal cue to step off the box and jump off of the floor “as quickly as possible”. Research conducted by Louder et al. (23) demonstrated that the use of this specific cue during the DJ lead to greater peak force production and minimised ground contact time, in comparison to other verbal cues. During unilateral testing, all subjects were required to land unilaterally during the second landing, ensuring that the entire test was truly unilateral throughout. Subjects were also told to maintain full extension throughout the lower-body during the flight phase of the jump. This was to ensure that dropping and jumping procedures were standardized, in line with research conducted by Pain (30). Any deviation from these instructions resulted in a void trial and the trial was retaken after 60-seconds. Recorded metrics included jump height, ground contact time (GCT), flight time, and reactive strength index (RSI – calculated from flight time divided by ground contact time).

Bilateral and Unilateral Standing Broad Jump (SBJ). For the SBJ, subjects were asked to stand with toes aligned to a black marker placed on the ground. Subjects were instructed to perform a horizontal jump after squatting to a self-selected depth, with the aim of jumping as far forward as possible. An arm-swing was allowed for this test owing to the increased difficulty in landing when hands are fixed to hips and the associated learning effect of horizontal jumping (1). All jump distances were recorded using a tape measure (which was fixed to the floor) to the nearest cm. Each jump was measured by placing a stick behind the subjects landing heel. Subjects were required to “stick the landing” to ensure foot and body position did not move upon landing, otherwise trials were excluded and retaken after a 60-second rest period, in line with research conducted by Bishop et al. (2).

30m Sprint. Electronic timing gates (Brower Timing Systems, Utah, USA) were positioned at 0, 10 and 30m, so split times could recorded at each time point. Subjects started each test from a stationary position. Their foot was placed 0.3 m behind the start line, with no rocking or moving forwards prior to the start of the test. Once the subjects and researcher were ready, the test began. The 30 m sprints began as soon as the subject broke the beam of the first timing gate sensors and ended when they broke the beam of the final timing gate. Subjects were asked to perform their sprints at maximal effort. The fastest time out of the three trials was used for further analysis.

505 Change of Direction Speed (CODS) test. Subjects completed the 505 change of direction test to assess CODS ability. This involved a linear sprint of 15 m, where timing gates were placed at 10 m. The time it took for the subjects to get from the 10 m to 15 m and back to 10 m was used to determine CODS performance. The turning leg was alternated on each repetition. In addition to this, a COD deficit time was calculated as a way of isolating CODS ability independent of sprint speed. The COD deficit was calculated by subtracting the 10 m time from the 505 time (27).

Statistical Analyses

Results were analysed using the Statistical Packages for Social Sciences (SPSS 24.0 for Mac, Chicago, IL, USA). Data were assessed for normality using the Shapiro-Wilk test. Absolute reliability was computed via the coefficient of variation (CV) (SD/mean)*100 (38) and standard error of measurement (SEM) SD*√(1-ICC) (15). Relative reliability was assessed using a two-way random intraclass correlation coefficient (ICC) with absolute agreement, inclusive of 95% confidence intervals. ICC's were interpreted in line with the scale proposed by Koo and Li (21) where values < 0.5 = poor, 0.5-0.75 = moderate, 0.75-0.9 = good, and > 0.9 = excellent. The magnitude of the BLD was calculated as a percentage using the equation proposed by Rejc et al. (32): BLD = 1 – (bilateral/(right + left))*100. A positive percentage score indicates the presence of a BLD, whilst a negative percentage is indicative of a bilateral facilitation (BLF), where the bilateral performance is superior to the summed unilateral performance. Pearson's *r* correlations were used to examine the relationships between BLD and sprint tests and 505 COD tests, with statistical significance set at $p \leq 0.05$.

RESULTS

All data were deemed normally distributed ($p > 0.05$). Mean test scores and reliability data for bilateral jump tests and sprint and CODS tests are presented in Table 1, whilst mean test scores and reliability data for unilateral jump tests are presented in Table 2. For bilateral jump tests, all CV were considered acceptable (< 10%) and relative reliability was good to excellent for all metrics (ICC = 0.79-0.95). For unilateral jumps, all CV values were < 10% with the exception of eccentric impulse on the right leg which was marginally greater (10.22%) and relative reliability was moderate to excellent for all metrics (ICC = 0.53-0.97). All CV values were ≤ 5.31% for both speed and CODS tests with relative reliability moderate to excellent for speed tests (ICC = 0.70-0.99) and moderate for the 505 test (0.59-0.68).

Figure 1 illustrates the BLD data for all jump tests with a BLD occurring across CMJ, SBJ and DJ metrics. However, this does not remain consistent for the DJ test, which showed a BLF for jump height and RSI. Pearson's *r* correlations between each BLD variable and speed/COD tests are presented in Table 3. A significant negative correlation was established between the BLD in CMJ jump height and 505 COD (left leg) ($r = -0.48$; $p = 0.04$), 505 COD (right leg) ($r = -0.53$; $p = 0.02$) and COD deficit (right leg) ($r = -0.59$; $p = 0.01$); CMJ concentric impulse and the 505 COD (left leg) ($r = -0.51$; $p = 0.03$), 505 COD (right leg) ($r = -0.64$; $p = 0.01$) and COD deficit (right leg) ($r = -0.60$; $p = 0.01$), and DJ flight time and 505 COD (left leg) ($r = -0.48$; $p = 0.04$).

*** INSERT TABLES 1-2 ABOUT HERE ***

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DISCUSSION

The aim of the present study was to examine the magnitude of the BLD during the CMJ, DJ and SBJ metrics and examine their relationships with linear speed and CODS performance. The findings suggest that the BLD is task-specific with vast differences reported between tests and metrics within the same test. In addition, a larger BLD in some jump metrics were related to faster CODS performance on both limbs for the 505 test, but only on the right limb for the change of direction (COD) deficit. No meaningful relationships were identified between the BLD and sprint speed over both 10 and 30 m.

The principle finding in the present study showed significant negative correlations between the BLD and CODS performance, but not linear speed. Specifically, the BLD during the CMJ for jump height (r = -0.48 to -0.53) and concentric impulse (r = -0.51 to -0.64) were significantly associated with the 505 test on both limbs. In addition, the same two metrics were negatively correlated with the COD deficit (jump height: r = -0.59; concentric impulse: r = -0.60), but only on the right leg. Given the lack of comparable research to date, drawing definitive conclusions is challenging. However, what can be stated is that because significant negative correlations were found with CODS performance, this supports the notion that it may be beneficial to be a competent jumper unilaterally. Intuitively, this makes sense given that CODS is characterized by unilateral movement patterns. In addition, it is plausible that a larger concentric impulse BLD may lead to improved CODS performance, because of a greater capacity to apply propulsive forces during the turning phase of the 505 test in a shorter period of time. It must also be remembered that if greater force is produced, entry velocity and the penultimate step before the COD task must be executed with effective technique (14). Effective braking strategies are underpinned by eccentric contractions, which if performed well, will likely result in a more efficient transition into the concentric push-off action during the subsequent COD manoeuvre. COD tasks are executed unilaterally for the most part (14); thus, it seems logical to suggest that athletes should be competent on one limb, especially where eccentric muscle contractions are required. However, readers should be mindful of this conclusion as the analysis is associative in nature and more in-depth analysis is warranted to fully corroborate this suggestion.

Furthermore, a significant negative correlation (*r* = -0.48) between the BLD in DJ FT and 505 COD (left leg) was present. Again, although speculative, this may indicate that subjects who demonstrate superior unilateral DJ performance (which manifests itself as a larger BLD), may also be better at the 505 test. The technical nature of the DJ test may in part explain these findings. The DJ requires a very specific transition from braking forces to propulsive forces; this represented by an athlete's ability to spend a shorter amount of time on the floor (25,31). Thus, if an athlete is competent at the DJ unilaterally as well, it is possible that they might exhibit a larger BLD. Furthermore, the 505 test is also governed by effective braking and re-accelerating ability (27). Thus, with both tests requiring similar physical qualities in order to execute them effectively, it seems logical to suggest that if a larger BLD is indicative of unilateral competency, that this is associated with faster CODS performance. However, statistical significance was only found on the left leg with the DJ, a test underpinned by vertical force production. Given that CODS is a mixture of both vertical and horizontal forces, this again demonstrates the task-specific nature of the BLD and poses the suggestion that measuring the BLD in multiple directions seems like a valid suggestion when aiming to determine its association with measures of performance. It should be acknowledged, that whilst it is possible that athletes could have been comparably poor at bilateral jumping, this seems an unlikely explanation for such a technically advanced jump (31).

The present study also identified no significant correlations between speed (10 and 30 m) and any BLD metric, which may represent a somewhat surprising finding. However, Bračič et al. (7) demonstrated how a smaller BLD may be favourable for pushing off the blocks during a sprint; however, no indication of sprint times were provided. Furthermore, it could be argued that a block-start is actually a bilateral task; thus, these findings in part support the results of the present study showing no significant association between the BLD and sprint performance. Given the lack of relationships in the present study, it seems logical to suggest that previously recognized factors such as developing strength would be a more advantageous physical quality to develop for enhanced acceleration performance (41). In addition, given that athletes may well have reached top speed at 30 m, the cyclical action of sprinting may be better enhanced by other qualities such as reactive strength (37) and sprint technique (26).

Recent research on interlimb asymmetries has highlighted the task-specific nature of side-to-side differences (2,3). However, comparable research on the BLD is scarce. Bračič et al. (7), reported a BLD of 19.1% in 12 elite sprinters and Van Soest et al. (40) observed a jump height BLD of 8.5% trained volleyball players. In the present study, the BLD varied considerably between metrics within the same test (Figure 1). For example, the CMJ showed a wide range of BLD values: jump height (12.67%), peak force (21.76%), eccentric impulse (28.24%), concentric impulse (31.91%) and peak power (19.53%). Similarly, the DJ test actually showed a BLF for two metrics: jump height (-7.18%) and RSI (-3.44%) in comparison to a large BLD for GCT (61.45%). Thus, the present study highlights the test and metric-specific nature of the BLD and highlights the importance of an in-depth analysis of this phenomenon. Furthermore, given that the DJ test showed a BLF and the CMJ did not, this may offer further support showing the advanced technical nature of reactive strength tasks. In essence, when left and right limbs were summed and still could not exceed the bilateral score, this demonstrates how challenging unilateral fast stretch-shortening cycle activities are. This is supported by Pain (30) who showed that both endurance and power-based athletes showed a BLF of -3.8 to -13.8% in power during the DJ test. Thus, with a wide variation in BLD scores across tests, it is suggested that this phenomenon is investigated with multiple metrics for each test.

Despite the aforementioned results, it is important to note a few limitations within this study. Firstly, a sample of physically active and healthy university students was utilised; thus, these findings are unlikely to be reflective of elite athlete populations. Furthermore, the nature of using a student sample may have impacted the findings, noting that earlier discussion highlighted the technical nature of the DJ test. Thus, future research should aim to replicate this study design with an elite athlete population. Secondly, a small sample size of 18 subjects was used. Therefore, future research should also aim to use a larger cohort of athletes and where possible, across age groups and genders, which will provide a useful base when trying to understand the relevance of the BLD on measures of athletic performance. Finally, limb dominance was not recorded for the present sample. This decision was made because the sample was reflective of a student population, not specific to one sport. However, practitioners working with homogenous populations (e.g., soccer athletes), should consider limb dominance analysis as well, which may go some distance to explaining why discrepancies exist between limbs during correlational analysis.

PRACTICAL APPLICATIONS

The findings of the present study highlight that a larger BLD is associated with faster 505 times; thus, this provides practitioners with useful evidence that competency at unilateral training is likely required. However, it should be acknowledged that these findings are applicable to collegiate students only. That said, practitioners working with team sport athletes can consider the principle of these findings, if done so with caution. During team sports, many actions occur unilaterally (i.e., sprinting, changing direction, kicking); therefore, it is necessary to be competent on one limb. From a training perspective, unilateral strength exercises such as split squats, step ups and single leg squats, and unilateral jumping exercises such as multi-planar single leg hops will aid in the development of unilateral movement competency. It should also be emphasized that bilateral training should in no way be ignored. With absolute load being greater during bilateral strength training, the potential for adaptation must not be forgotten. Given the inconclusive findings in the present study, the inclusion of unilateral exercises in conjunction with bilateral training is likely the most viable suggestion for practitioners.

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Table 1: Mean test data ± standard deviation (SD) and reliability statistics for bilateral jump test metrics, speed and change of direction speed tests.

Fitness Test/Metric	Mean ± SD	CV % (95% CI)	ICC (95% CI)	SEM
CMJ JH (m)	0.35 ± 0.06	4.51 (2.91-6.11)	0.92 (0.80-0.97)	0.02
CMJ PF (N)	1202.61 ± 388.59	3.45 (1.66-5.24)	0.95 (0.87-0.98)	88.61
CMJ ECC (Ns)	91.78 ± 20.81	6.27 (3.38-9.16)	0.89 (0.37-0.97)	7.03
CMJ CON (Ns)	188.22 ± 30.20	3.39 (1.96-4.82)	0.92 (0.81-0.97)	8.49
CMJ PP (W)	3909.28 ± 788.27	3.61 (1.81-5.41)	0.93 (0.82-0.97)	213.00
DJ JH (m)	0.28 ± 0.06	5.80 (3.80-7.84)	0.88 (0.70-0.95)	0.02
DJ GCT (s)	0.21 ± 0.05	4.02 (1.72-6.32)	0.83 (0.60-0.93)	0.02
DJ FT (s)	0.48 ± 0.05	2.76 (1.77-3.75)	0.91 (0.79-0.97)	0.02
DJ RSI	2.45 ± 0.53	5.28 (2.91-7.65)	0.79 (0.53-0.92)	0.24
SBJ Distance (m)	2.27 ± 0.28	3.06 (1.50-4.62)	0.88 (0.64-0.96)	0.10
10m (s)	1.85 ± 0.11	2.31 (0.97-3.65)	0.70 (0.37-0.88)	0.06
30m (s)	4.38 ± 0.31	0.57 (0.31-0.83)	0.99 (0.97-1.00)	0.03
505 COD-L (s)	2.52 ± 0.15	5.31 (3.02-7.74)	0.59 (0.26-0.78)	0.11
505 COD-R (s)	2.52 ± 0.18	3.55 (2.19-4.91)	0.68 (0.27-0.87)	0.10

CV = coefficient of variation; CI = confidence intervals; ICC = intraclass correlation coefficient; SEM = standard error of the measurement; CMJ = countermovement jump; JH = jump height; m = meters; PF = peak force; N = newtons; ECC = eccentric impulse; CON = concentric impulse; Ns = newton seconds; PP = peak power; W = watts; DJ = drop jump; GCT = ground contact time; s = seconds; FT = flight time; RSI = reactive strength index; SBJ = standing broad jump; L = left; R = right.

Table 2: Mean test data ± standard deviation (SD) and reliability statistics for unilateral jump test metrics.

Fitness Test/Metric	Mean ± SD Left	Mean ± SD Right	CV (% + 95% CI) Left	CV (% + 95% CI) Right	ICC (95% CI) Left	ICC (95% CI) Right	SEM Left	SEM Right
CMJ JH (m)	0.20 ± 0.04	0.20 ± 0.03	4.22 (2.40-6.04)	4.97 (3.14-6.81)	0.90 (0.76-0.96)	0.91 (0.79-0.97)	0.01	0.01
CMJ PF (n)	766.44 ± 203.11	767.44 ± 208.43	4.69 (2.80-6.62)	4.81 (3.25-6.37)	0.95 (0.88-0.98)	0.96 (0.90-0.99)	43.56	40.63
CMJ ECC (Ns)	64.22 ± 17.83	63.89 ± 12.96	6.51 (3.67-9.35)	10.22 (6.4-13.98)	0.90 (0.75-0.96)	0.74 (0.44-0.89)	5.69	6.63
CMJ CON (Ns)	140.33 ± 27.43	139.67 ± 25.88	3.28 (1.97-4.59)	2.72 (1.61-3.83)	0.95 (0.88-0.98)	0.97 (0.93-0.99)	6.07	4.40
CMJ PP (w)	2398.06 ± 504.07	2401.72 ± 489.63	3.86 (2.50-5.22)	3.04 (1.76-4.32)	0.95 (0.86-0.98)	0.97 (0.93-0.99)	118.47	85.40
DJ JH (m)	0.14 ± 0.05	0.14 ± 0.04	9.45 (5.93-12.97)	9.54 (5.78-13.30)	0.90 (0.76-0.96)	0.88 (0.70-0.95)	0.02	0.01
DJ GCT (s)	0.28 ± 0.02	0.27 ± 0.03	5.29 (3.82-6.76)	5.34 (2.67-8.01)	0.53 (0.13-0.79)	0.62 (0.21-0.84)	0.02	0.02
DJ FT (s)	0.33 ± 0.06	0.33 ± 0.05	5.23 (2.94-7.52)	5.53 (3.10-7.96)	0.91 (0.78-0.97)	0.83 (0.59-0.94)	0.02	0.02
DJ RSI	1.16 ± 0.24	1.22 ± 0.26	6.12 (3.36-8.88)	6.76 (4.45-9.07)	0.90 (0.59-0.97)	0.86 (0.68-0.95)	0.07	0.06
SBJ Distance (m)	1.74 ± 0.24	1.78 ± 0.24	2.74 (1.83-3.65)	2.49 (1.19-3.79)	0.95 (0.86-0.98)	0.93 (0.83-0.97)	0.05	0.06

CV = coefficient of variation; CI = confidence intervals; ICC = intraclass correlation coefficient; SEM = standard error of the measurement; CMJ = countermovement jump; JH = jump height; m = meters; PF = peak force; N = newtons; ECC = eccentric impulse; CON = concentric impulse; Ns = newton seconds; PP = peak power; W = watts; DJ = drop jump; GCT = ground contact time; s = seconds; FT = flight time; RSI = reactive strength index; SBJ = standing broad jump.

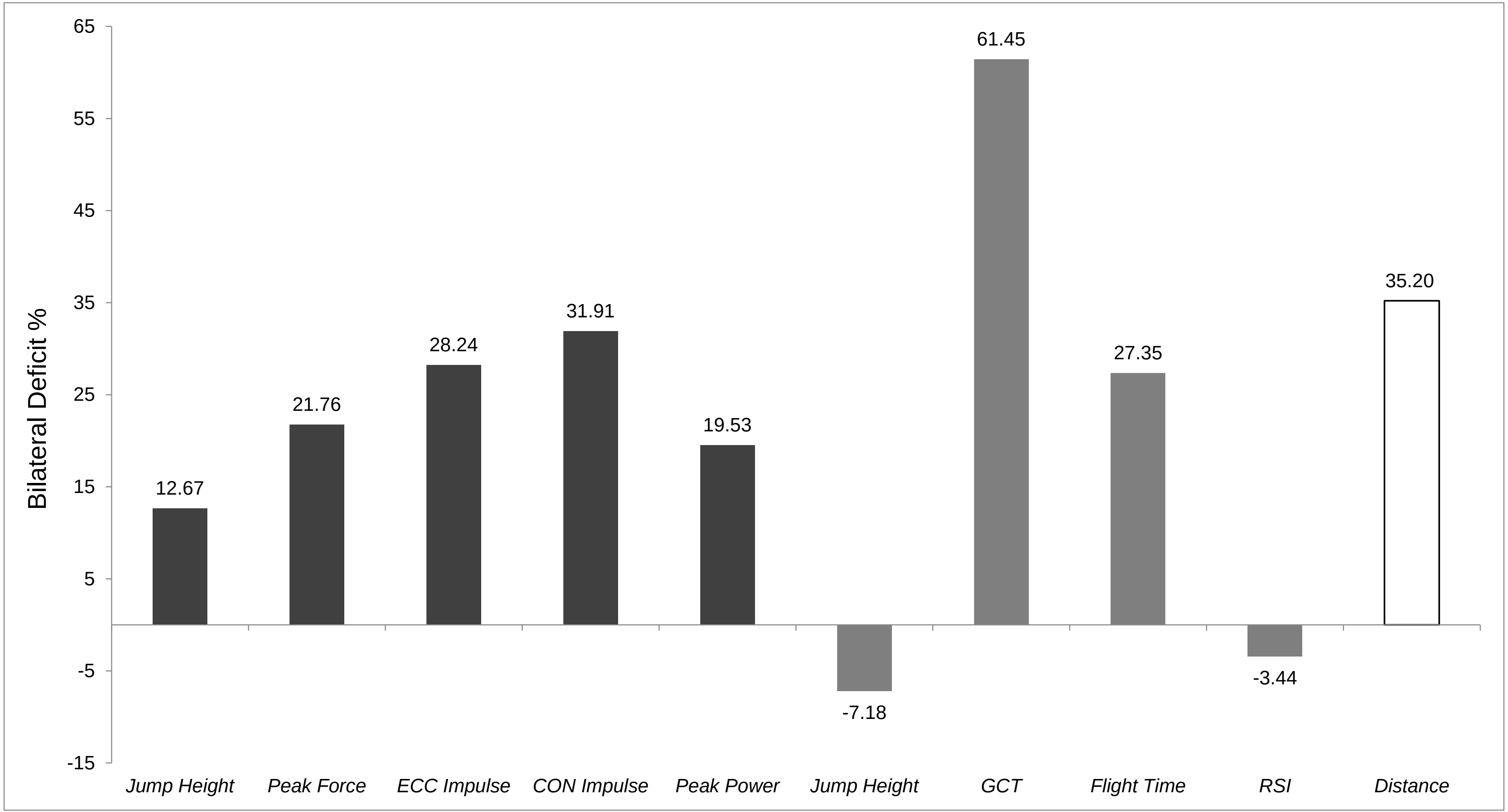

Figure 1: BLD percentages for the countermovement jump metrics (*jump height, peak force, eccentric impulse, concentric impulse and peak power*), drop jump metrics (*jump height, ground contact time [GCT], flight time and reactive strength index [RSI]*) and standing broad jump (*distance*).

Table 3: Pearson's *r* correlations between the bilateral deficit % scores and speed and change of direction speed data.

Bilateral Deficit (%)	**10m**	**30m**	**505 Left**	**505 Right**	**COD Deficit Left**	**COD Deficit Right**
CMJ JH	-0.22	-0.20	-0.48*	-0.53*	-0.46	-0.59*
CMJ PF	-0.17	-0.13	-0.10	-0.10	0.04	0.01
CMJ ECC	0.09	0.15	0.01	0.03	-0.08	-0.03
CMJ CON	-0.38	-0.31	-0.51*	-0.64**	-0.31	-0.60**
CMJ PP	-0.18	-0.08	-0.26	-0.39	-0.18	-0.42
DJ JH	-0.28	-0.43	-0.44	-0.35	-0.33	-0.28
DJ GCT	-0.33	-0.31	-0.34	-0.31	-0.14	-0.16
DJ FT	-0.28	-0.43	-0.48*	-0.37	-0.39	-0.30
DJ RSI	0.09	0.05	0.08	0.07	0.02	0.03
SBJ Distance	0.16	0.23	0.22	0.18	0.15	0.13

** correlation is significant at $p < 0.01$; * correlation is significant at $p < 0.05$.

CMJ = countermovement jump; JH = jump height; PF = peak force; ECC = eccentric impulse; CON = concentric impulse; PP = peak power; DJ = drop jump; GCT = ground contact time; FT = flight time; RSI = reactive strength index; SBJ = standing broad jump.