Comparing the Magnitude and Direction of Asymmetry during the Squat, Countermovement and Drop Jump Tests in Elite Youth Female Soccer Players

Abstract

The aims of the present study were to provide an in-depth comparison of inter-limb asymmetry and determine how consistently asymmetry favours the same limb during different vertical jump tests. Eighteen elite female under-17 soccer players conducted unilateral squat jumps (SJ), countermovement jumps (CMJ) and drop jumps (DJ) on a portable force platform, with jump height, peak force, concentric impulse and peak power as common metrics across tests. For the magnitude of asymmetry, concentric impulse was significantly greater during the SJ test compared to CMJ (p = 0.019) and DJ (p = 0.003). No other significant differences in magnitude were present. For the direction of asymmetry, Kappa coefficients revealed fair to substantial levels of agreement between the SJ and CMJ (Kappa = 0.35 to 0.61) tests, but only slight to fair levels of agreement between the SJ and DJ (Kappa = -0.26 to 0.18) and CMJ and DJ (Kappa = -0.13 to 0.26) tests. These results highlight that the mean asymmetry value may be a poor indicator of true variability of between-limb differences in healthy athletes. The direction of asymmetry may provide a useful monitoring tool for practitioners in healthy athletes, when no obvious between-limb deficit exists.

Key Words: Between-limb differences; kappa coefficient; limb dominance.

Introduction

Inter-limb asymmetry refers to the difference in performance or function between limbs [Bishop et al. 2018b; Keeley et al. 2011] and has been a popular line of investigation in recent years. Research has reported between-limb differences across a range of individual and team sports such as soccer [Bishop et al. 2018a; Bishop et al. 2018c], rugby [Marshall et al. 2015], cricket [Bishop et al. 2019a; Gray et al. 2016], basketball [Schiltz et al. 2009] and swimming [Dos'Santos et al. 2013]. In addition, multiple testing modalities have been used to quantify these differences. For strength, the isometric squat or mid-thigh pull [Bishop et al. 2019c; Dos'Santos et al. 2017], back squat [Sato and Heise, 2012] and isokinetic dynamometry [Costa Silva et al. 2015; Ruas et al. 2015] have all been used to detect side-to-side differences. Where jump testing is concerned, the countermovement jump (CMJ) [Bailey et al. 2015; Bell et al. 2014], drop jump (DJ) [Maloney et al. 2016] and their associated unilateral variations [Bishop et al. 2019b; Maloney et al. 2017] have all been used to quantify inter-limb asymmetries. When these studies are considered collectively, the take-home message is that inter-limb asymmetries are very task-specific. Thus, a single test is unlikely to show the "full picture" when aiming to quantify between-limb asymmetry [Bishop et al. 2019b; Loturco et al. 2018].

In soccer, jumping can occur up to 15 times per match [Faude et al. 2012; Nedelac et al. 2014]; thus, representing an ecologically valid method of determining lower body ballistic performance. Further to this, jump testing has been a common line of investigation for inter-limb asymmetry studies using soccer athletes. For example, Bishop et al. [2018c] showed that unilateral CMJ and hop tests resulted in between-limb imbalances for jump height and distance of 12.5% and ~6% respectively in youth female players. In male academy soccer players, it has been reported jump height asymmetries for the unilateral CMJ of 5.8, 7.1 and 9.0% in under-23, under-18 and under-16 year old players respectively [Bishop et al. 2018a]. Finally, in a separate study by Bishop et al. [2019a], adult female soccer players reported inter-limb differences in jump height of 8.7 and 9.2% during the unilateral CMJ and DJ tests respectively. Despite this information, the aforementioned studies only provide asymmetry data for outcome measures (e.g., jump height or distance). Given the aforementioned task-specific nature of asymmetry, a more in-depth analysis of the magnitude of asymmetry (via the use of force plates) seems warranted, comparing across jump tasks as this allows some understanding of athletes' jump strategy in addition to outcome measures alone.

An emerging line of investigation for this topic is the 'direction of asymmetry'. This refers to the limb that could be considered dominant, by virtue of the asymmetry consistently favouring the same side [Maloney 2018]. Recent work by Bishop et al. [2019b] used Kappa coefficients to determine how consistently asymmetry favoured the same limb between test sessions for jump height and peak force (unilateral CMJ) and jump height and reactive strength index (unilateral DJ). Results showed substantial levels of agreement for asymmetry during the CMJ (Kappa = 0.64-0.66) and fair to moderate levels of agreement during the DJ (Kappa = 0.36-0.56). Additional work by Bishop et al. [2018d] again used Kappa coefficients to determine levels of agreement for the direction of asymmetry; however, this was done for concentric and eccentric impulse metrics only during the unilateral CMJ and broad jump tests. Levels of agreement were substantial for concentric impulse between tests (Kappa = 0.79); however, all other Kappa values ranged from slight to fair (Kappa = < 0.01-0.32). Thus, this evidence indicates that the direction of asymmetry may be just as variable as the magnitude. Furthermore, it seems logical that this would be a useful line of investigation on the topic of asymmetry, especially in healthy youth athletes when there is no obvious reason for a between-limb deficit. This also appears especially valuable for female soccer players for two reasons. Firstly, previous research has highlighted female athletes can exhibit greater asymmetries than their male counterparts [Bailey et al. 2015]. Secondly, previous studies on this topic have highlighted that asymmetries are a likely by-product of playing soccer [Bishop et al. 2019a], owing to the positional differences and repeated high-intensity actions such as changing direction, jumping, kicking [Taylor et al. 2017] which are unlikely to occur in an even amount on both limbs.

Therefore, given the task and variable dependent nature of asymmetry, a more in-depth analysis of asymmetries in variables pertaining to jump strategy across different tests is warranted. In addition, further investigation of the direction of asymmetry is required to more fully elucidate the consistency of 'limb dominance' in various jumping tasks and related test variables. Thus, the aims of the present study were twofold: 1) provide an in-depth comparison of inter-limb asymmetries between the unilateral squat jump (SJ), CMJ and DJ tests and, 2) determine how consistently asymmetry favours the same limb across each test for common metrics.

Methods

Participants

Eighteen elite under-17 female soccer players (age: 15.9 ± 0.8 years; body mass: 57.8 ± 7.0 kg; height: 165.2 ± 6.5 cm; 14 right foot dominant, 4 left foot dominant) from the same professional team participated in this study. Despite the low number of participants in the present study, previous literature has suggested the need to interpret asymmetry on an individual basis [Bishop et al. 2018d], owing to its variable nature. The testing battery was conducted 6-weeks before the "Brazilian Sub-17 Women's Soccer Championship", the most important Brazilian youth soccer tournament for this age-category, during the pre-season training period. All players had a history of only minor muscular injuries, were free from injury at the time of testing and in the preceding 3-months. Prior to participation in the study, written parental consent and participant ascent was obtained. The study was approved by the Anhanguera-Bandeirante University Ethics Committee.

Study Design

The soccer players performed all tests on the same day in the following order: unilateral SJ, CMJ and DJ from a box height of 20 cm. Previous research on the topic of asymmetry has shown that jump height from the unilateral CMJ and DJ tests are associated with reduced speed and change of direction speed performance in soccer players [Bishop et al. 2018a; Bishop et al. 2018c]. In addition, a needs analysis for soccer has indicated that lower body power and reactive strength are important physical characteristics for soccer players [Turner and Stewart, 2014]. When combined with commonality of unilateral movement patterns in the sport [Bishop et al. 2019a], these three tests were deemed appropriate for the study design. As a final point, to the authors' knowledge, there is limited information to date on inter-limb asymmetries during the SJ; thus, the addition of this test as a comparison to the CMJ and DJ tests would provide useful information on the topic. The athletes arrived at the sports laboratory in a fasted state for 2-hours and free of caffeine for at least 24-hours. All athletes were previously familiarized with the testing procedures due to their constant physical assessments conducted throughout the soccer season. A 5-minute rest interval was provided between jump tests. A standardized warm-up was performed first consisting of moderate to light self-selected runs for 5-minutes and specific sub-maximal attempts for each jump test.

Unilateral Jump Tests

For the SJ and CMJ tests, players were instructed to step onto a portable force platform (AccuPower, AMTI, Graz, Austria) sampling at 400 Hz. For the SJ, players were instructed to descend into a squat position on each limb with the knee flexed to approximately 90° and hold for 2-seconds before rapidly extending the hips, knees and ankles, without any subsequent countermovement. If any visible countermovement was noted by the tester, trials were deemed void and subsequently retaken after a 30-second rest period. For the CMJ, players were instructed to execute a downward movement to a self-selected depth followed by a rapid extension of the hips, knees and ankles prior to take-off. Both the SJ and CMJ tests were executed with hands on hips, required players to maintain a straight jumping limb during the flight phase of the jump, with instructions to jump as high as possible. The non-jumping limb was required to remain slightly flexed at the hip and knee, with instructions to avoid additional swinging which would have influenced jump performance. For the unilateral DJ, players started on a 20 cm box and were instructed to step off the box with the chosen limb (hands on hips) and land on the same limb, with the instructions to minimize ground contact time and maximize jump height. A total of five attempts were performed for each jump, interspersed by 30-second rest intervals and the best jump from each test was retained for further analysis. The following variables were automatically obtained from the custom designed software (AccuPower 3.0 AMTI, Graz, Austria) of the force plate for all jumps: jump height, peak force (propulsive), concentric impulse and peak power and defined in line with suggestions from Chavda et al. [2018]. Jump height was defined as the maximum height achieved calculated from velocity at take-off squared divided by 2*9.81 (where 9.81 equals gravitational force). Peak force was defined as the maximum net force output during the propulsive phase of the jump and concentric impulse was defined as the net force multiplied by the time taken to produce it; i.e., the area under the force-time curve. Peak power was defined as the maximum power obtained during the propulsive phase of the jump. When calculating metrics for the DJ, velocity at impact needed to be quantified first and was estimated by multiplying the box height in metres by gravitational force (0.2*9.81) resulting in a velocity of -1.96 $m \cdot s^{-1}$ [Blazevich, 2007]. This enabled comparable metrics to be computed across all jump tests using the impulse-momentum method.

Statistical Analyses

All data were recorded in Microsoft Excel™ as means ± standard deviations (SD) and later transferred to SPSS (version 25.0; SPSS, Inc., Armonk, NY, USA) for additional analyses when required. Within-session reliability was determined for each metric using the coefficient of variation (CV) with 95% confidence intervals and a two-way random intraclass correlation coefficient (ICC) with absolute agreement and 95% confidence intervals. CV values < 10% were considered acceptable [Cormack et al. 2008] and ICC values were interpreted in accordance with suggestions from Koo and Li, [2016] where values > 0.9 = excellent, 0.75-0.9 = good, 0.5-0.75 = moderate, and < 0.5 = poor.

Mean inter-limb asymmetries were computed using a standard percentage difference equation for both jump tests: 100/(max value)*(min value)*-1+100, which has been suggested to be accurate for the quantification of asymmetries from unilateral tests [Bishop et al. 2018b; Bishop et al. 2018d]. When depicting inter-limb differences individually, the use of an 'IF function' in Microsoft Excel was added on the end of the formula: *IF(left<right,1,-1) [Bishop et al. 2018d; Bishop et al. 2019b], in order to show the direction of asymmetry (i.e., which leg produces the larger score) without altering the magnitude.

A repeated measures ANOVA was performed to determine systematic bias between asymmetry values between jump tests with an alpha level set at $p < 0.05$. Magnitude of change for asymmetry was also calculated using Cohen's d effect sizes (ES): $(Mean_{test1} – Mean_{test2})/SD_{pooled}$ with values interpreted in line with suggestions from Hopkins et al. [2009] where < 0.20 = trivial; 0.20-0.60 = small; 0.61-1.20 = moderate; 1.21-2.0 = large; 2.01-4.0 = very large. Finally, Kappa coefficients were calculated to determine the levels of agreement for the direction of asymmetry. This method was chosen because the Kappa coefficient describes the proportion of agreement between two methods after any agreement may have occurred by chance [Cohen 1960]. Kappa values were interpreted in line with suggestions from Viera and Garrett, [2005] where 0.01-0.20 = slight; 0.21-0.40 = fair; 0.41-0.60 = moderate; 0.61-0.80 = substantial; 0.81-0.99 = nearly perfect.

Results

Within-session reliability data are shown in Table 1. All data showed acceptable CV values with the exception of slightly higher variability for concentric impulse on the right leg during the SJ and PF on the left leg during the DJ. ICC values ranged from moderate to excellent in the SJ (0.71-0.98), good to excellent in the CMJ (0.87-0.96) and moderate to excellent in the DJ (0.59-0.96). Jump data and the magnitude of asymmetry for each metric are presented in Tables 2 and 3 respectively. The repeated measures ANOVA showed significantly larger mean asymmetry values for concentric impulse in the SJ test compared to the CMJ (p = 0.019) and DJ (p = 0.003). No other significant differences in asymmetry were present between tests. When computing ES data, differences in asymmetry between the SJ and CMJ ranged from trivial to moderate (0.09-0.80). When comparing asymmetry between the SJ and DJ, differences ranged from trivial to moderate (0.15-0.98). When comparing asymmetry between the CMJ and DJ, differences ranged from small to moderate (0.29-0.64).

** INSERT TABLES 1-3 HERE **

Kappa coefficients and descriptive levels of agreement are presented in Table 4. When comparing the direction of asymmetry between the SJ and CMJ tests, Kappa values ranged from fair to substantial (0.35 to 0.61). When comparing the SJ with the DJ, Kappa values ranged from slight to fair (-0.26 to 0.18). When comparing the CMJ with the DJ, Kappa values ranged from slight to fair (-0.13 to 0.26). Owing to the variable nature in both the magnitude and direction of asymmetry, individual between-limb differences are presented for jump height (Figure 1), peak force (Figure 2), concentric impulse (Figure 3) and peak power (Figure 4).

** INSERT TABLE 4 AND FIGURES 1-4 HERE **

Discussion

The aims of the present study were twofold: 1) provide an in-depth comparison of inter-limb asymmetries between the unilateral SJ, CMJ and DJ tests and, 2) determine how consistently asymmetry favours the same limb across each test for common metrics. For the magnitude of asymmetry, results showed that concentric impulse showed significantly larger asymmetry values in the SJ than the CMJ and DJ tests. No other significant differences in asymmetry were shown. For the direction of asymmetry, levels of agreement across jump tests were quite poor in healthy elite youth female soccer players.

Table 2 shows the mean test data for each metric in the three jump tests. The most notable finding is the lack of significant difference seen in jump height between the CMJ and SJ tests. Providing a definitive conclusion for these findings is challenging. Previous literature has indicated that the use of the stretch-shortening cycle (SSC) during the CMJ, often results in increased jump heights of 18-20% [Bosco et al. 1982] or 2-4 cm [Bobbert & Casius, 2005] when compared to the SJ. However, these suggestions are based off bilateral jump data. Although speculative, it is plausible that the SSC was detrimentally affected in the present study, by the use of unilateral test methods. Furthermore, regardless of the underlying reason, this highlights the need for more unilateral plyometric training in the present sample of youth female soccer players.

Table 3 shows the mean inter-limb asymmetry values for each metric in the three jump tests. In this sample of elite youth female soccer players, it appears that concentric impulse was the most sensitive at detecting between-limb imbalances. Specifically, this metric in the SJ test produced significantly greater asymmetry values than the CMJ and DJ, representing a moderate ES (0.80-0.98). Given the present study did not investigate muscle activation during test protocols, providing a definitive conclusion for this occurrence is challenging. However, with impulse being defined as net force x time [Chavda et al. 2018], it seems plausible to suggest that players may have changed their jump strategy on each limb in a test where they are required to hold a half squat position (SJ) prior to take-off. Further to this, holding such a position unilaterally is likely to be both challenging and somewhat un-natural, which may have contributed to the heightened asymmetry shown for concentric impulse. However, further research into impulse asymmetry between jump tests are required in order to determine whether this is a consistent occurrence.

Kappa coefficients were used to assess the direction of asymmetry in the present study; specifically, to see how consistently asymmetry favoured the same limb for common metrics across three jump tests. To the authors' knowledge, this is the first study to do this across more than two jump tests. Results showed that when comparing the SJ and DJ, and the CMJ and DJ tests, levels of agreement for the direction of asymmetry were slight to fair (Table 4), suggesting that inter-limb differences rarely favour the same limb across tests for a common metric. In contrast, levels of agreement were better when comparing the SJ and CMJ tests, particularly for peak power asymmetry which showed a substantial level of agreement (Kappa = 0.61). Despite all tests being vertical jumps, the noticeably better levels of agreement between the SJ and CMJ can likely be attributed to the similarity in movement between the two tests.

Equally, it may also highlight the inherent difference of the DJ test and how this translates to the direction of asymmetry. These results are in agreement with Bishop et al. [2018d] who reported slight to substantial levels of agreement between eccentric and concentric impulse in the CMJ and broad jump tests. In summary, given levels of agreement for the direction of asymmetry were typically low, this precludes the use of using a single test to detect inter-limb asymmetries in adult female soccer players. Furthermore, given the variable nature of both the magnitude and direction of asymmetry, it is suggested that analysis of asymmetry must be done at an individual level, which has been suggested previously [Bishop et al. 2019b; Bishop et al. 2018d; Loturco et al. 2018].

Figures 1-4 show individual asymmetry values for each metric across jump tests. When the three jump tests are considered together, 9/18 (50%) players showed asymmetry on the same side for jump height, 7/18 (39%) showed asymmetry on the same side for peak force, 6/18 (33%) showed asymmetry on the same side for concentric impulse, and 11/18 (61%) showed asymmetry on the same side for peak power. Given the present sample were healthy athletes tested in pre-season, and free from injury for 3-months in the build up to the start of the competitive season, there is arguably no obvious reason why substantial between-limb deficits should exist. Thus, it is suggested that for healthy youth athletes, the direction of asymmetry is just as important as the magnitude, especially when looking to monitor changes in asymmetry over time. In addition, when individual asymmetry data are viewed for jump height (Figure 1), peak force (Figure 2) and peak power (Figure 4), there is a trend for the direction of asymmetry to favour the left limb (i.e., non-preferred kicking limb). This data does not seem surprising given that the non-preferred kicking limb must stabilise during the action of kicking, which has been previously shown to be associated with improved kicking accuracy [Hart et al. 2014].

While these observations provide new insights into the assessment of functional asymmetry, this study has a couple of limitations that should be considered. Firstly, there was only access to a single force platform during testing; thus, testing needed to be conducted unilaterally in order to quantify inter-limb differences. Previous literature has highlighted that unilateral testing could be a more appropriate method for detecting side-to-side imbalances as there is no involvement from the other limb [Bishop et al. 2017]. However, the assessment of bilateral asymmetries may have been a useful addition to the present study, particularly for the SJ test. Thus, future research should aim to establish the consistency in the direction of asymmetry between comparable bilateral and unilateral test measures. Secondly, all measurements in the present study were conducted in the vertical direction. Given that soccer players are required to be proficient in multiple planes of movement [Turner and Stewart, 2014], future research should also test for inter-limb asymmetries in the horizontal and lateral planes of motion [Lockie et al. 2014].

Conclusion

In summary, the magnitude of asymmetry is significantly greater in the SJ test when analyzing concentric impulse, with no other significant differences across jump tests. The direction of asymmetry appears highly variable; thus, practitioners should consider individual analysis when reporting inter-limb differences. For soccer athletes, the non-preferred kicking limb often scored better on the selected jump tests and practitioners should be mindful of such imbalances given that improved symmetry has been previously shown to be associated with enhanced kicking accuracy.

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Table 1. Within-session reliability data (95% confidence intervals) for each jump test.

Test Reliability	**Squat Jump**		**Countermovement Jump**		**Drop Jump (20 cm)**	
	Left	*Right*	*Left*	*Right*	*Left*	*Right*
CV (%):						
Jump height (cm)	6.52 (4.51-8.53)	6.02 (4.40-7.63)	6.39 (4.27-8.50)	7.21 (4.44-9.97)	5.74 (3.18-8.29)	8.77 (5.39-12.14)
Peak force (N)	3.71 (2.49-4.94)	2.68 (1.77-3.60)	4.16 (2.64-5.68)	4.08 (2.53-5.63)	11.08 (6.97-15.19)	9.53 (5.83-13.24)
CON impulse (N·s)	8.64 (3.01-14.28)	12.03 (4.52-19.54)	4.36 (2.69-6.02)	4.23 (2.22-6.23)	3.83 (1.06-6.60)	4.12 (2.73-5.52)
Peak power (W)	4.16 (2.83-5.50)	3.87 (2.44-5.29)	4.74 (3.21-6.26)	4.39 (2.70-6.08)	3.51 (1.77-5.24)	4.79 (3.46-6.12)
ICC:						
Jump height (cm)	0.91 (0.79-0.96)	0.95 (0.88-0.98)	0.91 (0.80-0.96)	0.88 (0.72-0.95)	0.83 (0.52-0.94)	0.67 (0.16-0.87)
Peak force (N)	0.97 (0.94-0.99)	0.98 (0.95-0.99)	0.95 (0.89-0.98)	0.96 (0.90-0.98)	0.60 (0.12-0.85)	0.65 (0.15-0.87)
CON impulse (N·s)	0.75 (0.46-0.90)	0.71 (0.37-0.88)	0.94 (0.88-0.98)	0.95 (0.90-0.98)	0.90 (0.75-0.96)	0.96 (0.89-0.99)
Peak power (W)	0.96 (0.92-0.99)	0.97 (0.92-0.99)	0.92 (0.83-0.97)	0.95 (0.90-0.98)	0.76 (0.35-0.91)	0.84 (0.56-0.94)

CV = coefficient of variation; CON = concentric; cm = centimetres; N = Newtons; N·s = Newton seconds; W = watts; ICC = intraclass correlation coefficient.

Table 2. Mean test data ± standard deviations for all jump tests (*n* = 18).

Jump Metric	**Squat Jump**		**Countermovement Jump**		**Drop Jump (20 cm)**	
	Left	*Right*	*Left*	*Right*	*Left*	*Right*
Jump height (cm)	13.43 ± 1.78	12.68 ± 2.14	12.92 ± 1.89	11.82 ± 1.51	13.35 ± 1.75	13.04 ± 1.83
Peak force (N)	1114.50 ± 50.70	1081.37 ± 140.44	1101.47 ± 171.82	1077.17 ± 176.84	1352.45 ± 307.62	1238.79 ± 202.29
CON impulse (N·s)	284.07 ± 78.92	300.97 ± 101.74	265.58 ± 37.10	261.35 ± 40.95	210.55 ± 37.97	220.66 ± 36.72
Peak power (W)	1589.66 ± 223.58	1541.04 ± 245.72	1526.09 ± 206.28	1445.80 ± 206.92	1457.27 ± 114.49	1397.09 ± 121.59

CON = concentric; cm = centimeters; N = Newtons; N·s = Newton seconds; W = watts.

Table 3. Mean inter-limb asymmetry values and effect size (ES) data for comparable metrics between jump tests.

Asymmetry Metric	SJ (%)	CMJ (%)	DJ (%)	SJ vs. CMJ ES (95% CI)	SJ vs. DJ ES (95% CI)	CMJ vs. DJ ES (95% CI)
Jump height	8.88 ± 7.73	11.50 ± 8.80	7.91 ± 4.73	0.32 (-0.34 to 0.97)	0.15 (-0.50 to 0.81)	0.51 (-0.16 to 1.17)
Peak force	6.21 ± 4.66	6.62 ± 4.41	12.56 ± 12.33	0.09 (-0.56 to 0.74)	0.68 (0.01 to 1.35)	0.64 (-0.03 to 1.31)
CON impulse	16.84 ± 15.77	7.51 ± 4.68[a]	5.48 ± 4.20[b]	0.80 (0.12 to 1.48)	0.98 (0.29 to 1.68)	0.46 (-0.21 to 1.12)
Peak power	6.14 ± 5.25	6.99 ± 6.47	5.40 ± 4.24	0.14 (-0.51 to 0.80)	0.16 (-0.50 to 0.81)	0.29 (-0.37 to 0.95)

[a] = significantly lower asymmetry than SJ test ($p = 0.019$); [b] = significantly lower asymmetry than SJ test ($p = 0.003$).

CON = concentric; SJ = squat jump; CMJ = countermovement jump; DJ = drop jump; CI = confidence intervals.

Table 4. Kappa coefficients and descriptive levels of agreement showing how consistently inter-limb asymmetry favours the same limb across jump tests.

Asymmetry Metric	SJ vs. CMJ		SJ vs. DJ		CMJ vs. DJ	
	Kappa Coefficient	*Descriptor*	*Kappa Coefficient*	*Descriptor*	*Kappa Coefficient*	*Descriptor*
Jump height	0.45	Moderate	0.02	Slight	0.26	Fair
Peak force	0.35	Fair	-0.26	Fair	0.09	Slight
CON impulse	0.44	Moderate	0.11	Slight	-0.13	Slight
Peak power	0.61	Substantial	0.18	Slight	0.26	Fair

CON = concentric; SJ = squat jump; CMJ = countermovement jump; DJ = drop jump.

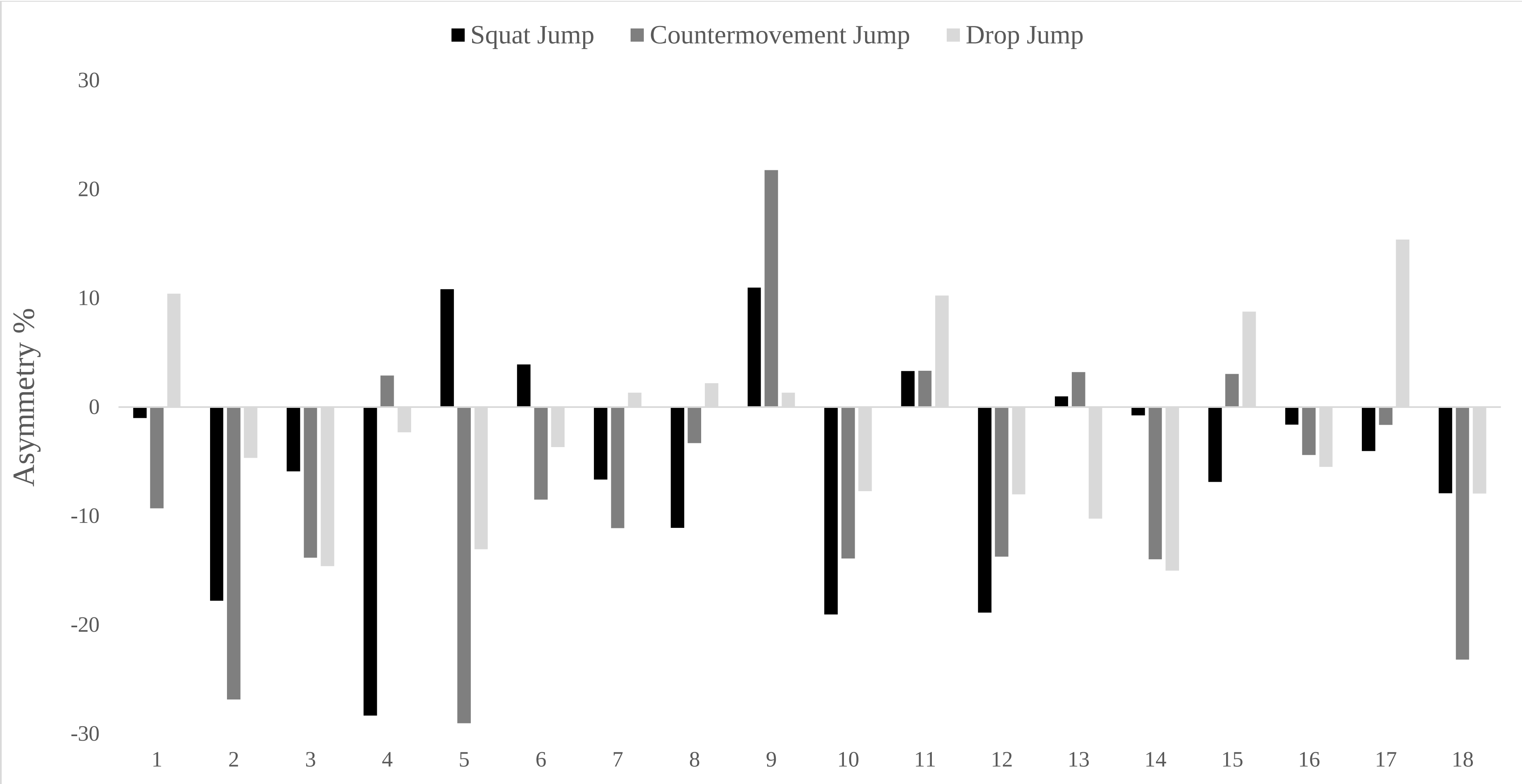

Figure 1. Individual asymmetry data for jump height across tests. N.B: above 0 indicates right leg dominance and below 0 indicates left leg dominance.

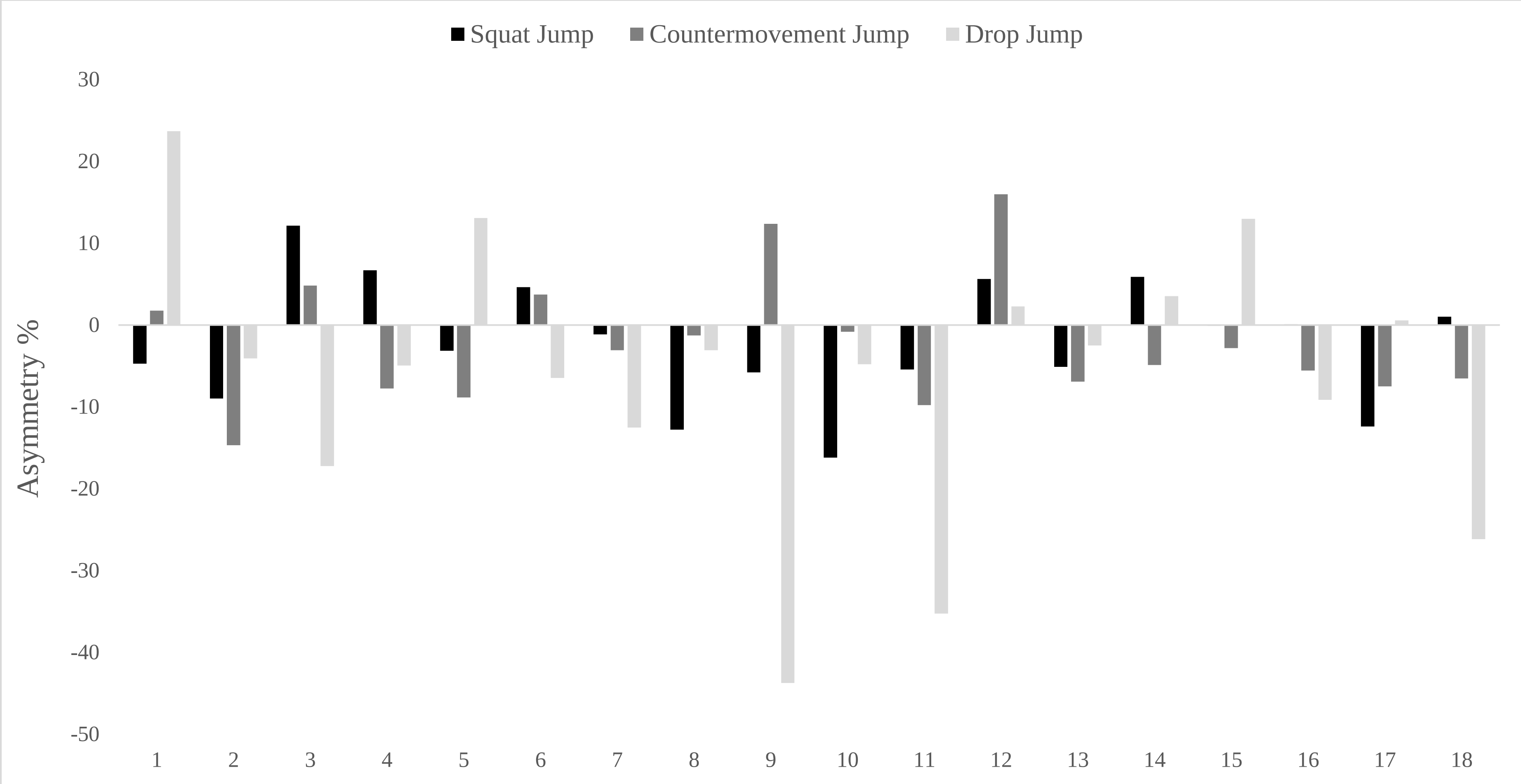

Figure 2. Individual asymmetry data for peak force across tests. N.B: above 0 indicates right leg dominance and below 0 indicates left leg dominance.

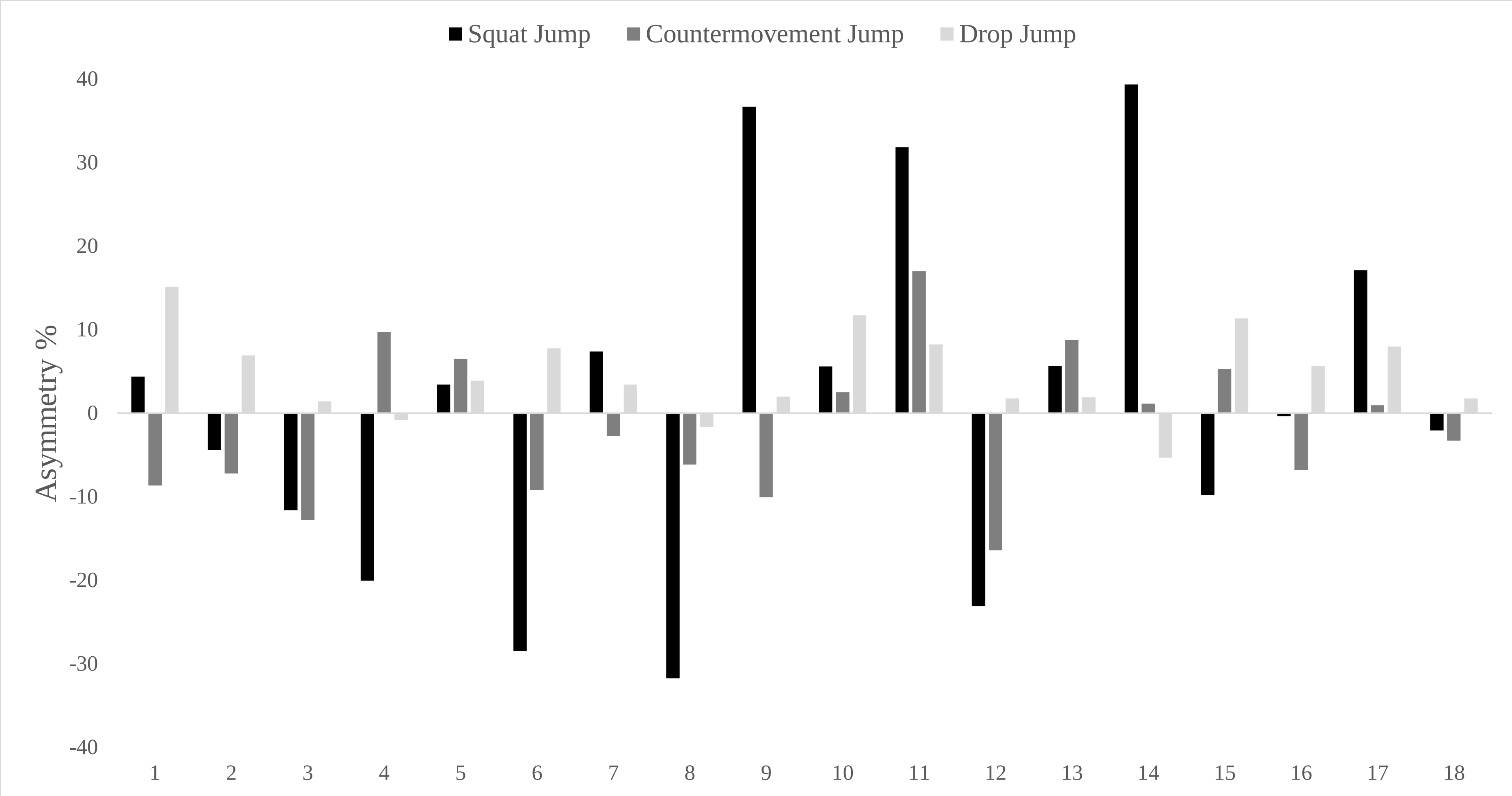

Figure 3. Individual asymmetry data for concentric impulse across tests. N.B: above 0 indicates right leg dominance and below 0 indicates left leg dominance.

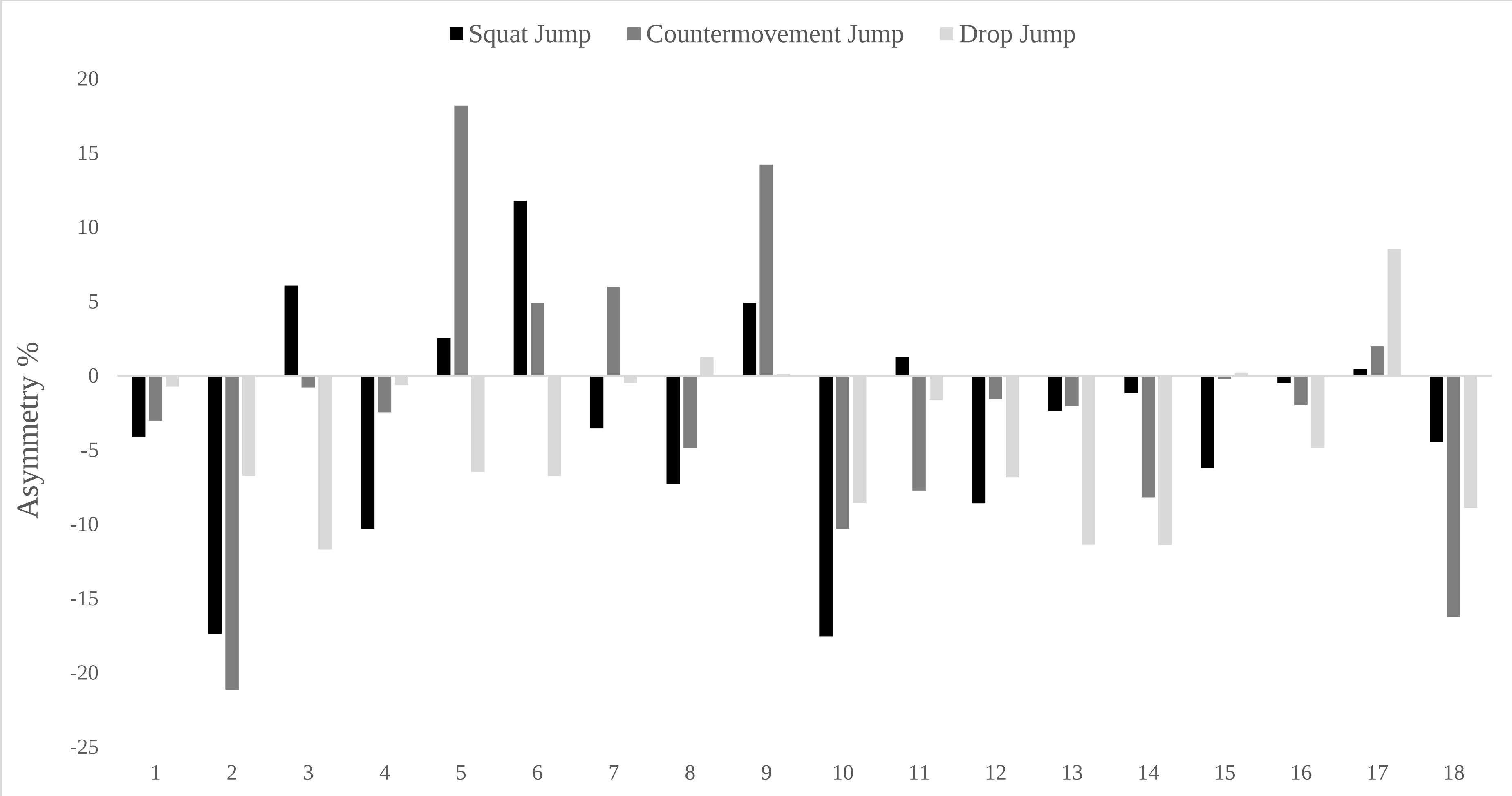

Figure 4. Individual asymmetry data for peak power across tests. N.B: above 0 indicates right leg dominance and below 0 indicates left leg dominance.