Bilateral vs. Unilateral Countermovement Jumps: Comparing the Magnitude and Direction of Asymmetry in Elite Academy Soccer Players

Abstract

The aims of the present study were to compare the magnitude and direction of asymmetry in comparable bilateral and unilateral countermovement jumps (CMJ). Forty-five elite academy soccer players from under-23 (*n* = 15), under-18 (*n* = 16) and under-16 (*n* = 14) age groups performed bilateral and unilateral CMJ as part of their routine pre-season fitness testing. For the magnitude of asymmetry, no significant differences were evident for any metric between tests. However, eccentric impulse asymmetry was significantly greater than mean force and concentric impulse in both bilateral and unilateral tests ($p < 0.01$). For the direction of asymmetry, Kappa coefficients showed poor levels of agreement between test measures for all metrics (mean force = -0.15; concentric impulse = -0.07; eccentric impulse = -0.13). Mean jump data was also presented relative to body mass for each group. For the bilateral CMJ, significant differences were evident between groups, but showed little consistency in the same group performing better or worse across metrics. For the unilateral CMJ, eccentric impulse was the only metric to show meaningful differences between groups, with the under-18 group performing significantly worse than under-23 and under-16 players. This study highlights that despite the magnitude of asymmetry being similar for each metric between comparable bilateral and unilateral CMJ, consistency in the direction of asymmetry was poor. In essence, if the right limb produced the larger force or impulse during a bilateral CMJ, it was rare for the same limb to perform superior during the unilateral task. Thus, practitioners should be aware that bilateral and unilateral CMJ present different limb dominance characteristics and should not use one test to represent the other when measuring between-limb asymmetries.

Key Words: Inter-limb differences; limb dominance; levels of agreement.

Introduction

Soccer is a high-intensity intermittent sport which requires players to develop a wide variety of physical characteristics for optimal physical performance. For example, previous literature has highlighted that players can jump up to 15 times (28) and perform up to 168 high-intensity actions inclusive of accelerations and decelerations (30) per match. In addition, seminal research from Bangsbo (1) highlighted that elite players can change direction between 1200-1400 times in a match, with physical duals also suggested as key areas in competitive match-play (35). Thus, the development of jumping, sprint and change of direction speed (CODS) ability are likely to be pivotal for physical development in all soccer players (31). In addition, given that one limb is often favoured for key actions such as kicking, tackling and jumping, equal loading on each limb seems unlikely. Thus, the development of inter-limb asymmetries seems expected for soccer athletes.

There has been a rise in empirical investigations relating to asymmetry and soccer athletes, across a range of ages. For example, Bishop et al. (8) reported inter-limb differences of ~6% for the single, triple and crossover hop for distance tests, but also 12.5% for jump height during the single leg countermovement jump (SLCMJ), in youth female players. Associative analysis showed that jump height asymmetries were significantly correlated with slower 5, 10 and 20-m speed (r =0.49-0.59). Loturco et al. (24) reported between-limb asymmetries in the bilateral countermovement jump (CMJ) and squat jump (SJ) tests in adult female players. Asymmetries were reported for jump height (CMJ = 10.6%; SJ = 9.8%), peak force (CMJ = 3.9%; SJ = 5.3%), peak power (CMJ = 7.8%; SJ = 7.1%) and landing force (CMJ = 5.9%; SJ = 5.4%). However, no meaningful associations with speed or CODS were evident. Finally, Bishop et al. (3) reported jump height asymmetries from the SLCMJ of 5.7, 7.1 and 9.0% in under-23, under-18 and under-16 elite academy players, respectively. Furthermore, numerous strong correlations were evident with 5 (r =0.60-0.86), 10 (r =0.54-0.87), 20-m speed (r =0.56-0.79) and 505 (r =0.61-0.85) performance, all of which suggested that larger imbalances were associated with slower speed and CODS times. As such, there is conflicting evidence surrounding the magnitude of asymmetry given that the aforementioned studies have used both bilateral and unilateral tests across different age groups in soccer. Thus, further research in this area is warranted.

Another recent line of investigation on the topic of asymmetry is in relation to the 'direction of imbalance'. When considering jump tests, this refers to the leg that produced the larger score and provides an understanding of limb dominance in a given task (26). Bishop et al. (4) reported levels of agreement for the direction of asymmetry across unilateral isometric squat, CMJ and broad jump tests in 28 recreational sport athletes. When comparing peak force asymmetry across tasks, levels of agreement ranged from poor to slight (Kappa = -0.34 to 0.05), where the Kappa describes the levels of agreement once any agreement due to chance has been removed (12). In addition, when comparing impulse asymmetry between jumps, levels of agreement were typically poor to fair (Kappa = -0.25 to 0.32), with the exception of concentric impulse which showed substantial levels of agreement (Kappa = 0.79). In a separate study, Bishop et al. (5) compared the direction of asymmetry using the unilateral CMJ, SJ and drop jump (DJ) tests in elite under-17 female soccer players. Reported asymmetry metrics included jump height, peak force, concentric impulse and peak power for all jump tests. Levels of agreement were determined between the same metrics across tests and varied considerably; CMJ vs. SJ (Kappa = 0.35-0.61; fair to substantial), CMJ vs. DJ (Kappa = -0.13 to 0.26; poor to fair), SJ vs. DJ (Kappa = -0.26 to 0.18; poor to slight). These data show that the direction of asymmetry often exhibits notable differences between tasks, but is arguably not that surprising given asymmetry has been shown to be highly task-specific (5,16,21,23,25,29). However, it is worth noting that the aforementioned studies were attempting to establish levels of agreement between notably different tasks. In addition, although previous research has investigated comparisons between bilateral and unilateral jump tests (32,36), to the authors' knowledge, no study has investigated how the direction of asymmetry varies between comparable bilateral and unilateral CMJ. Previous research has already shown that limb differences may exist for impulse but not landing forces (36); however, this was only during the unilateral CMJ. Thus, comparing asymmetry characteristics (i.e., magnitude and direction) in both bilateral and unilateral jumping is yet to be investigated.

Therefore, the primary aim of the present study was to compare the magnitude and direction of asymmetry between bilateral and unilateral CMJ tests. Given limited information in this regard has been conducted in the past, developing a true hypothesis was challenging. However, it was hypothesized that the direction of asymmetry would exhibit notable differences between tests with no significant differences evident for the magnitude of asymmetry.

Methods

Experimental Approach to the Problem

This study used a single session design with jump testing occurring as part of a routine fitness testing battery during the start of the 2019-2020 soccer pre-season. All players were familiar with bilateral and unilateral CMJ testing; thus, test familiarization was deemed sufficient on the day. Bilateral testing occurred on twin force plates (ForceDecks, London, UK) sampling at 1000 Hz and for unilateral testing, the right plate was used when testing the right leg and vice versa. Both the magnitude and direction of asymmetry were calculated for both tests enabling a comparison of inter-limb differences in two different ways using elite academy soccer athletes.

Subjects

Forty-five elite academy players from a Category 1 soccer academy in the Premier League™ volunteered to participate in the present study. A minimum of 42 participants were determined from a priori power analysis using G*Power (Version 3.1, University of Dusseldorf, Germany) using the ANOVA: fixed effects, omnibus, one-way test. This implemented statistical power of 0.8, a type 1 alpha level of 0.05 which was able to determine an effect of 0.5, and has been used in comparable literature (15). Subjects were from three different age categories: under-23 (n = 15; height = 1.83 ± 0.07 m; body mass = 76.36 ± 8.03 kg), under-18 (n = 16; height = 1.80 ± 0.05 m; body mass = 74.40 ± 5.80 kg) and under-16 (n = 14; height = 1.73 ± 0.06 m; body mass = 63.02 ± 6.47 kg). All subjects had a minimum of five years competitive soccer experience and two years structured strength and conditioning training experience. Owing to the testing occurring at the beginning of pre-season, no major or minor injuries were reported at the time of testing or in the preceding eight weeks. This study was approved by the *deleted for peer review* research and ethics committee.

Bilateral and Unilateral Countermovement Jumps

Prior to data collection, all players completed a standardized warm up consisting of 5-minutes of light jogging, followed by a single set of 10 repetitions of bodyweight squats, forward and lateral lunges and forward and lateral leg swings. Practice trials for both jumps were provided at approximately 75, 90 and 100% of the players' perceived maximal effort. Three minutes of rest was provided between the last practice trial and the first recorded jump, with test order randomized for all athletes.

For data collection, hands were positioned on hips which were required to remain in the same position for the duration of all testing. Jumps were initiated by performing a countermovement to a self-selected depth before accelerating vertically as fast as possible into the air, with specific test instructions to "jump as high as you can" and for the legs to remain fully extended during the flight phase of the jump. For unilateral testing, the non-jumping leg was slightly flexed with the foot hovering at mid-shin level, and no additional swinging of this leg was allowed. Recorded metrics included mean force, concentric impulse and eccentric impulse, with definitions for their quantification conducted in line with suggestions by Chavda et al. (11) and McMahon et al. (27). Mean force was defined as the average force output during the propulsive phase of the jump prior to take-off (11,27). Concentric impulse was defined as the integral of force between the moment the system reached zero velocity until take-off (11,27). Eccentric impulse was defined as the integral of force between the start of the countermovement and the moment the system mass reached zero velocity (11,27). These metrics were chosen in order to directly compare the magnitude and direction of asymmetry between comparable bilateral and unilateral tests. All subjects performed three trials of each test, with 90 seconds of rest provided between trials and three minutes between tests. The average of all trials was used for subsequent analysis.

Statistical Analyses

All force-time data were exported to Microsoft Excel™, expressed as means and standard deviations (SD), and later transferred into SPSS (version 25.0; SPSS, Inc., Armonk, NY, USA) for additional analyses. Normal distribution was determined using the Shapiro-Wilk test which confirmed normality for test scores, but not asymmetry data. Within-session absolute reliability was quantified using the coefficient of variation (CV) and relative reliability using a 2-way random ICC (single measures) with absolute agreement inclusive of 95% confidence intervals (34). The CV was calculated via the formula: (SD[trials 1-3]/average[trials 1-3]*100) with values ≤ 10% suggested to be considered acceptable (14). ICC values were interpreted in line with suggestions by Koo and Li (22) where scores > 0.9 = excellent, 0.75-0.9 = good, 0.5-0.75 = moderate, and < 0.5 = poor.

To determine systematic bias, a repeated measures ANOVA was used for test scores between age groups, and a Friedman's ANOVA used for asymmetry data. When comparing statistical significance between bilateral and unilateral data for the magnitude of asymmetry, a paired samples Wilcoxon test was used, with significance being set at $p < 0.05$. The magnitude of change was calculated between age groups for test data using Cohen's *d* effect sizes (ES) with 95% confidence intervals using the formula: $(Mean_1 – Mean_2)/SD_{pooled}$ (13), where 1 and 2 represent the respective age groups in question. These were interpreted in line with Hopkins et al. (19) 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; and > 4.0 = near perfect.

Inter-limb asymmetries were quantified as a percentage difference between limbs using an average of all trials on each limb with the formula: (100/(maximum value)*(minimum value)*-1+100), as proposed by Bishop et al. (6). 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) (4,5), in order to show the direction of asymmetry, without altering the magnitude. Kappa coefficients were calculated to determine the levels of agreement for how consistently an asymmetry favored the same side between bilateral and unilateral tests; thus, providing the direction of asymmetry. This method was chosen because the Kappa coefficient describes the proportion of agreement between two methods after any agreement by chance has been removed (12). Kappa values were interpreted in line with suggestions from Viera and Garrett (33), where ≤ 0 = poor, 0.01-0.20 = slight, 0.21-0.40 = fair, 0.41-0.60 = moderate, 0.61-0.80 = substantial and 0.81-0.99 = almost perfect.

Results

Table 1 shows mean test data, asymmetry scores and within-session reliability data. For the bilateral CMJ, all metrics exhibited good to excellent relative reliability (ICC = 0.88-0.96) and acceptable absolute reliability (CV ≤ 9.23%). For the unilateral CMJ, all metrics showed moderate to good relative reliability (ICC = 0.70-0.89) with mean force and concentric impulse showing acceptable absolute reliability (CV ≤ 9.18%). In contrast, eccentric impulse exhibited the greatest variability with CV values of 13.34-13.42%. In addition to this heightened variability, eccentric impulse asymmetry was significantly greater than mean force and concentric impulse asymmetry during both tests ($p < 0.01$). However, no significant interaction effect was evident for the magnitude of asymmetry between tests for any metric.

For the direction of asymmetry, Kappa coefficients showed poor levels of agreement between tests for all metrics: mean force = -0.15, concentric impulse = -0.07, eccentric impulse = -0.13. Owing to the lack of normal distribution and agreement between test methods for the direction of asymmetry, individual asymmetry data have been provided in Figures 1-3 and highlight the variable nature of scores, regardless of test method.

Table 2 shows mean test data and accompanying effect sizes with 95% confidence intervals, by age group. For the bilateral CMJ, the under-16 group displayed significantly reduced mean force and concentric impulse on both limbs compared to the other two age groups ($p < 0.01$; ES range = -1.02 to -1.62), and significantly lower eccentric impulse on the right leg only compared to the under-18 group ($p < 0.05$; ES = -0.76). For the unilateral CMJ, the under-16 group again showed significantly reduced mean forces on both limbs compared to the older age groups ($p < 0.01$; ES range = -1.32 to -1.78), and significantly lower concentric and eccentric impulse on both limbs compared to the under-23 group ($p < 0.05$; ES range = -0.73 to -0.88).

***** Insert Table 1 about here *****

***** Insert Figure 1-3 about here *****

***** Insert Table 2 about here *****

Discussion

The aim of the present study was to compare the magnitude and direction of asymmetry between bilateral and unilateral CMJ tests. Results showed similar magnitudes of asymmetry for metrics when compared between bilateral and unilateral versions of the CMJ, but eccentric impulse did exhibit significantly greater asymmetry than mean force and concentric impulse in both tests. Despite similarities in the magnitude of asymmetry between tests, the direction of asymmetry showed poor levels of agreement, indicating that if an asymmetry favours one limb during a bilateral CMJ, it rarely favours the same side during unilateral testing.

Table 1 shows the mean asymmetry scores for both jump tests. Interestingly, it would appear that mean force, concentric and eccentric impulse exhibit similar magnitudes of asymmetry, regardless of whether being tested bilaterally or unilaterally. In addition, despite eccentric impulse being able to detect larger side-to-side differences compared to mean force and concentric impulse, it is suggested that these results should be interpreted in line with test variability. Previous research has suggested that asymmetry can be compared against the CV, in order to determine what is considered real asymmetry or within the error of the test (17). However, when considering the unilateral CMJ, despite mean asymmetry being slightly greater than the CV, it must be acknowledged that this metric showed somewhat questionable reliability, with CV values > 13%. This is in part supported by Bishop et al. (7) who despite reporting large asymmetry values for rate of force development (22.91%) and impulse (25.46%) during the first 100 milliseconds of a unilateral isometric squat, also showed that CV values were 26 and 32%, respectively. Thus, with suggestions of acceptable variability of < 10% (14), practitioners may wish to be cautious of monitoring eccentric impulse during the unilateral CMJ, owing to its heightened variability. In contrast, eccentric impulse showed similar asymmetry when testing bilaterally and acceptable absolute reliability. Thus, if practitioners deem this an appropriate metric to monitor for their athletes, they are advised to select the bilateral CMJ. Furthermore, if unilateral test measures are also deemed relevant, sufficient familiarization procedures should be adhered to in an attempt to reduce test variability scores for a metric like eccentric impulse.

When considering the direction of asymmetry, results showed that the bilateral and unilateral CMJ exhibited opposing trends. All Kappa coefficients were poor (< 0), indicating that limb dominance was almost never the same between tasks. This is represented by Figures 1-3, which show the highly variable nature of asymmetry. Specifically, only 19 out of 45 players exhibited asymmetries on the same limb between tests for mean force, and 20 out of 45 for both concentric and eccentric impulse metrics. These data show that the majority of players exhibited different limb dominance characteristics during the bilateral and unilateral CMJ. Although we believe this is the first study to compare the direction of asymmetry between comparable bilateral and unilateral jump tests, the Kappa values are, in part, contrasting with previous studies. Bishop et al. (5) compared the direction of asymmetry between unilateral CMJ, drop jump and squat jump tests, with levels of agreement ranging from poor to substantial between tests (Kappa = -0.26 to 0.61). Similarly, a separate study by Bishop et al. (4) compared the direction of asymmetry for force and impulse metrics from the unilateral isometric squat, CMJ and broad jump tests, with levels of agreement again, ranging from poor to substantial between tests (Kappa = -0.34 to 0.79). Given the present study did not perform any mechanistic investigation, providing a true reasoning for the consistent poor levels of agreement is challenging. However, previous literature has suggested that examining asymmetry during bilateral and unilateral testing is likely not the same thing (2,10), given that force production is spread across both limbs when jumping bilaterally (2) and no contribution from the opposing limb is present when on one leg (10). Thus, if practitioners wish to examine asymmetry, they are advised to consider which method provides the most appropriate representation of their athletes movement patterns in their sport and select accordingly. Furthermore, and as previously mentioned, not all metrics appear reliable during unilateral testing; thus, practitioners should be mindful of any metrics which show variability > 10%.

Table 2 shows mean jump scores, with the data showing just how variable jump strategy can be and how important it is to present such findings relative to body mass. For example, during the bilateral CMJ, both concentric and eccentric impulse showed differing trends between groups, highlighting that different information is likely to be obtained from phase-specific components of the CMJ. In addition, this metric monitors how much force is being produced over time prior to take-off and has been shown to be a more appropriate metric to monitor to detect alterations in jump strategy than outcome measures, such as jump height (18). For example, Gathercole et al. (18) administered the Yo-Yo protocol on 11 collegiate team-sport athletes and used the bilateral CMJ to detect acute changes in jump performance immediately after, 24 and 72 hours post intervention. Jump height showed trivial to small reductions (ES = 0.08-0.34), whereas net impulse showed trivial to moderate reductions (ES = 0.20-0.69), with the authors suggesting that alternative variables which monitor jump strategy are useful to detect changes in jump performance. As such, practitioners are advised to be clear on which metrics they are monitoring and why, as the variable nature of these metrics between age groups appears evident, even during a bilateral CMJ.

In contrast, the unilateral CMJ appeared to show somewhat less complexity in the findings. No meaningful differences in mean force or concentric impulse were evident between groups. However, eccentric impulse was significantly reduced for the under-18 group compared to under-23's. Previous research comparing bilateral and unilateral CMJ, indicated that greater variability was evident in the movement patterns of a bilateral CMJ (2). Furthermore, previous literature has also suggested that unilateral tests may be more indicative of true capacity (10), given that no contribution exists from the opposing limb. Therefore, given that no obvious pattern was evident between tests or age groups in the present study, it appears that they offer different information when considering mean force and impulse metrics. Thus, given the notable differences exhibited in test scores from the bilateral CMJ and its superior reliability compared to the unilateral CMJ, it is perhaps suggested that bilateral jump testing is favourable for monitoring both test and asymmetry data.

Despite the usefulness of this study, it is not without its limitations which should be acknowledged. Firstly, although the sample were accustomed with the chosen test protocols, no familiarization session was conducted. This seems like a relevant point given that eccentric impulse showed elevated CV values (> 10%) when quantified from the unilateral CMJ. Thus, test familiarization should be seen as a key aspect of collecting usable and reliable data. Secondly, this study only provided data for a single test session. Previous research has highlighted a distinct lack of longitudinal data pertaining to asymmetry (9), and with the variable nature of asymmetry (5,16,21,23,25,29), a repeated measures design would further aid our understanding on the topic. Finally, these data were collected at the beginning of pre-season and with testing being so close to the off-season period, may not fully represent the jump capacity of the players. Therefore, future research may wish to consider changes in jump performance and asymmetry across a competitive season.

Practical Applications

Given that jump testing is so commonly employed in routine fitness testing batteries, these data provide athletes with a useful understanding of both the magnitude and direction of asymmetry for vertical jump testing. Owing to the enhanced reliability of all metrics in the bilateral CMJ and its ability to detect 'real' asymmetries (greater than the CV) for all reported metrics, practitioners are advised to select bilateral jump testing to detect differences between age groups and monitor asymmetry.

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Table 1. Within-session reliability data of bilateral and unilateral countermovement jump metrics.

Test/Metric	Mean ± SD	Asymmetry (%)	CV (%)	ICC (95% CI)
CMJ:				
Mean Force-L (N)	749.56 ± 106.80	6.92 ± 6.17	3.62	0.92 (0.87-0.97)
Mean Force-R (N)	736.35 ± 101.81		3.90	0.91 (0.85-0.96)
Concentric Impulse-L (N·s)	191.07 ± 32.51	6.46 ± 6.38	5.88	0.90 (0.81-0.94)
Concentric Impulse-R (N·s)	186.89 ± 31.54		5.34	0.91 (0.84-0.94)
Eccentric Impulse-L (N·s)	145.17 ± 44.88	12.12 ± 9.02*	7.62	0.92 (0.85-0.96)
Eccentric Impulse-R (N·s)	139.33 ± 40.77		9.23	0.85 (0.73-0.92)
UCMJ:				
Mean Force-L (N)	1199.05 ± 162.41	5.51 ± 4.44	5.12	0.79 (0.60-0.86)
Mean Force-R (N)	1200.22 ± 178.14		5.03	0.82 (0.66-0.90)
Concentric Impulse-L (N·s)	143.34 ± 32.70	7.71 ± 6.65	9.18	0.68 (0.42-0.81)
Concentric Impulse-R (N·s)	146.66 ± 35.51		8.71	0.86 (0.74-0.92)
Eccentric Impulse-L (N·s)	33.70 ± 9.08	14.48 ± 10.67*	13.34	0.74 (0.51-0.85)
Eccentric Impulse-R (N·s)	34.54 ± 9.73		13.42	0.69 (0.43-0.83)

* significantly greater than mean force and concentric impulse asymmetry ($p < 0.01$).

CV = coefficient of variation; ICC = intraclass correlation coefficient; CI = confidence intervals; CMJ = countermovement jump; L = left; R = right; N = Newtons; N·s = Newton seconds; UCMJ = unilateral countermovement jump.

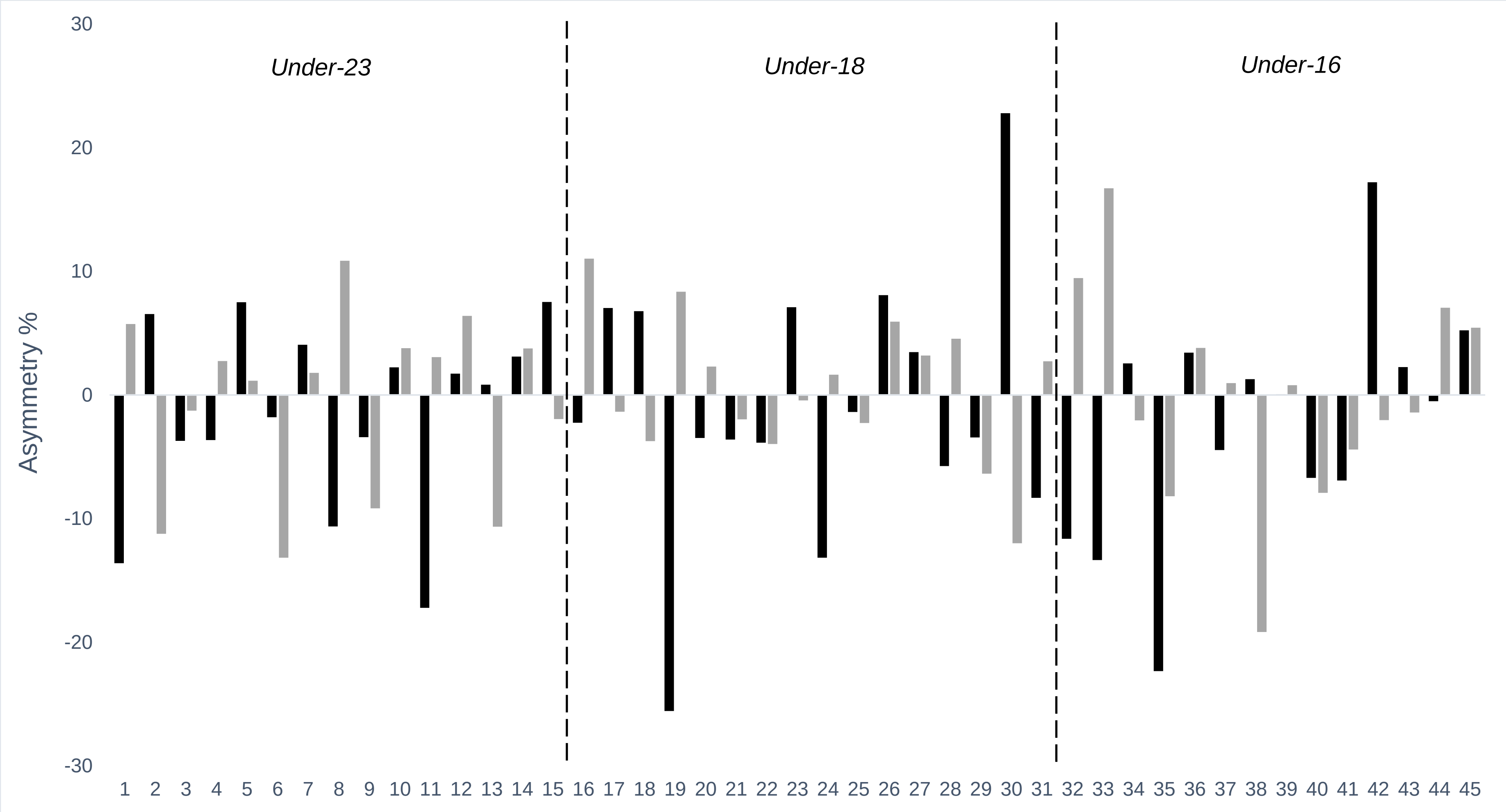

Figure 1. Individual asymmetry data for mean force during the countermovement (black) and unilateral countermovement jump (grey). N.B: above the 0 line means right leg dominant and below 0 means left leg dominant (Kappa = -0.15; poor).

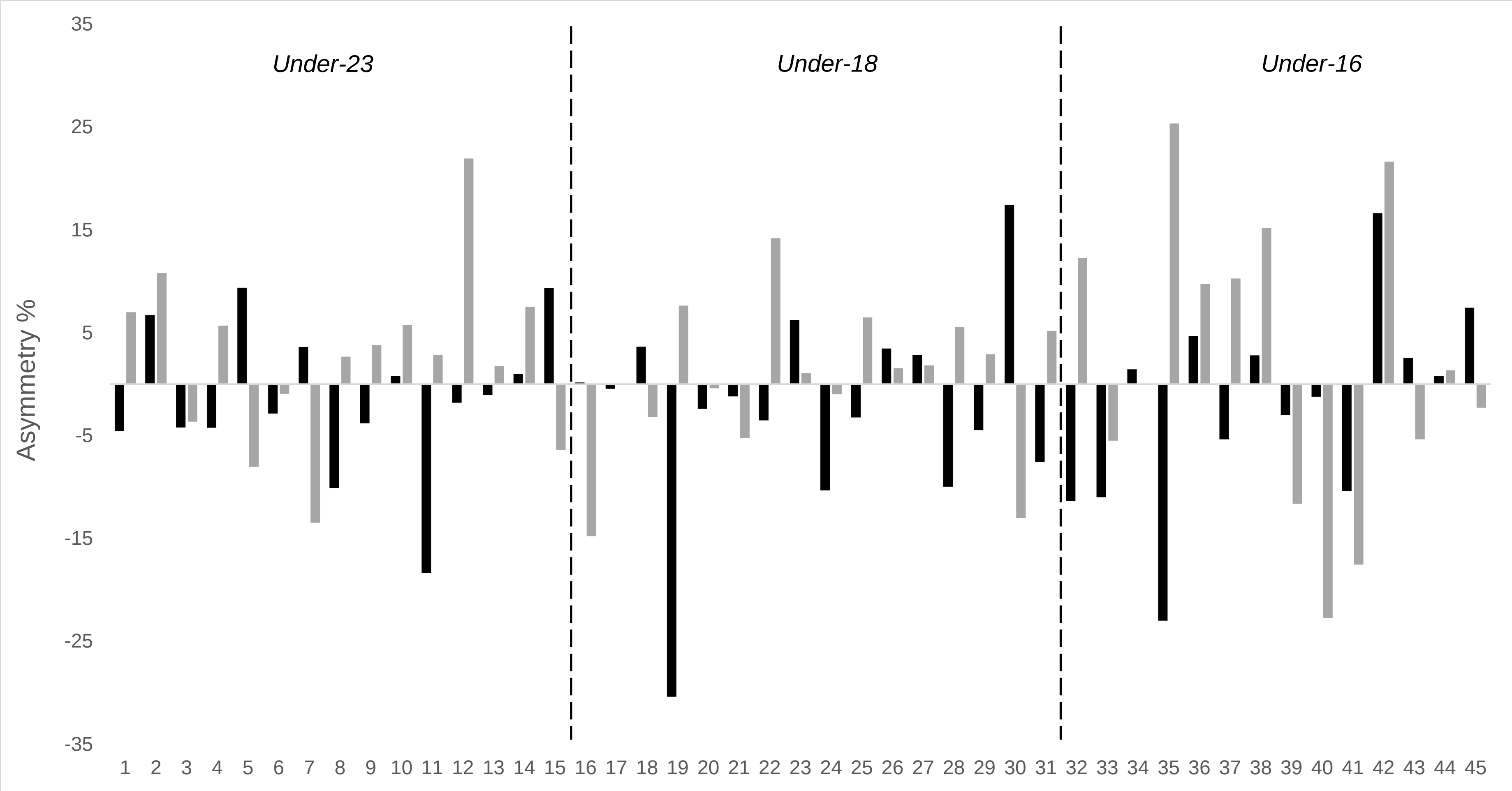

Figure 2. Individual asymmetry data for concentric impulse during the countermovement (black) and unilateral countermovement jump (grey). N.B: above the 0 line means right leg dominant and below 0 means left leg dominant (Kappa = -0.07; poor).

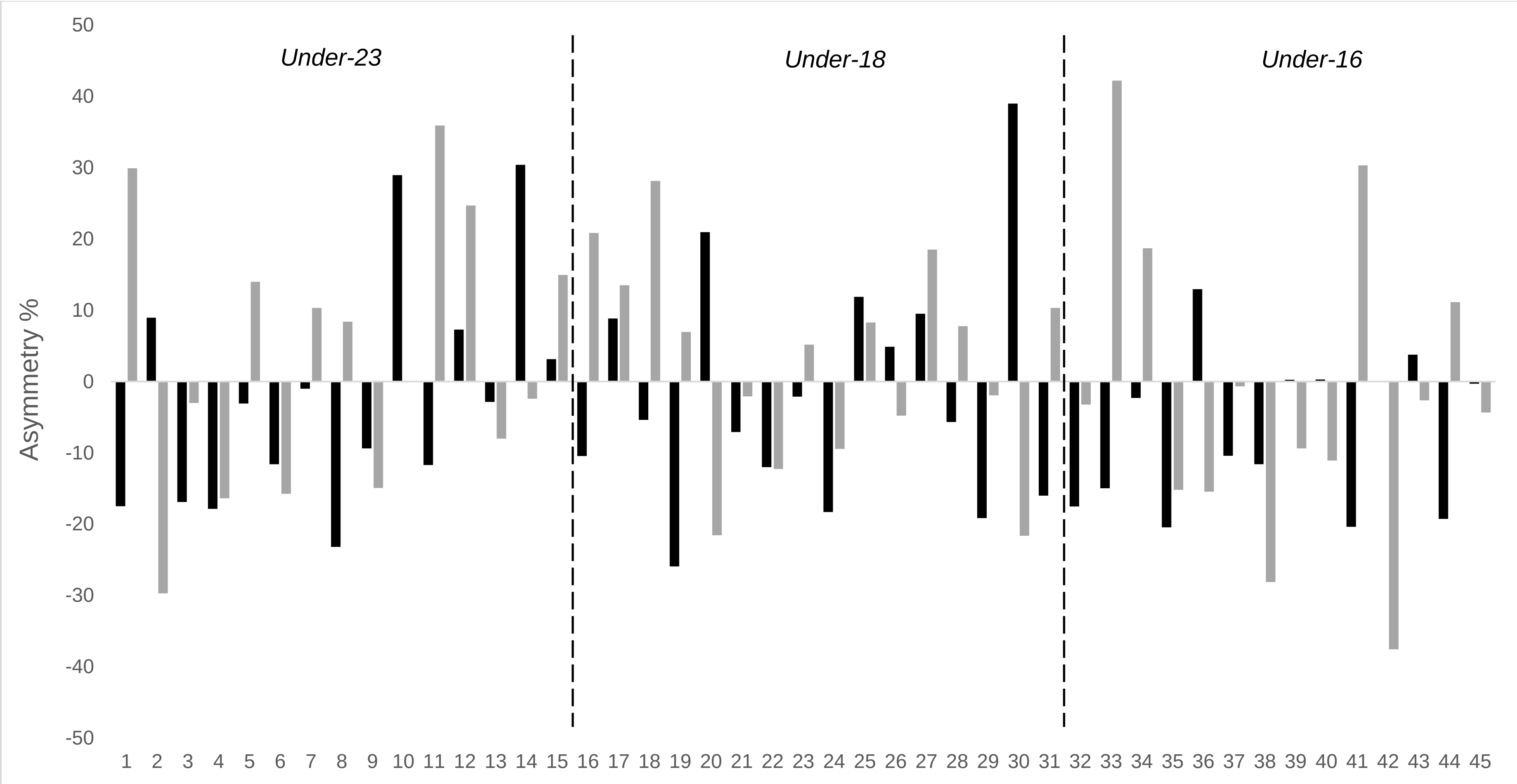

Figure 3. Individual asymmetry data for eccentric impulse during the countermovement (black) and unilateral countermovement jump (grey). N.B: above the 0 line means right leg dominant and below 0 means left leg dominant (Kappa = -0.13; poor).

Table 2. Mean relative test scores by age group and accompanying effect size data.

Test/Metric	Mean ± Standard Deviation			Effect Size (95% Confidence Intervals)		
	Under-23	*Under-18*	*Under-16*	*U23 vs. U18*	*U23 vs. U16*	*U18 vs. U16*
CMJ:						
MF-L (N/kg)	10.50 ± 0.92	10.35 ± 1.17	10.70 ± 1.09[c]	-0.14 (-0.32 to 0.03)	0.20 (0.00 to 0.39)	0.31 (0.12 to 0.50)
MF-R (N/kg)	10.36 ± 1.08	10.21 ± 0.78	10.43 ± 1.10[d]	-0.16 (-0.34 to 0.02)	0.06 (-0.13 to 0.26)	0.23 (0.04 to 0.42)
CON-L (N·s/kg)	2.69 ± 0.36	2.70 ± 0.27	2.62 ± 0.30[b,d]	0.03 (-0.14 to 0.21)	-0.21 (-0.41 to -0.02)	-0.28 (-0.47 to -0.09)
CON-R (N·s/kg)	2.65 ± 0.32	2.63 ± 0.29	2.56 ± 0.28[b]	-0.07 (-0.24 to 0.11)	-0.30 (-0.50 to -0.10)	-0.25 (-0.44 to -0.05)
ECC-L (N·s/kg)	1.93 ± 0.48	2.10 ± 0.57[a]	2.06 ± 0.67[b]	0.32 (0.15 to 0.50)	0.22 (0.03 to 0.42)	-0.06 (-0.26 to 0.13)
ECC-R (N·s/kg)	1.87 ± 0.44	2.06 ± 0.51[a]	1.90 ± 0.59[d]	0.40 (0.22 to 0.58)	0.06 (-0.14 to 0.25)	-0.29 (-0.48 to -0.10)
UCMJ:						
MF-L (N/kg)	16.81 ± 1.80	16.78 ± 1.51	16.88 ± 1.83	-0.02 (-0.19 to 0.16)	0.04 (-0.16 to 0.23)	0.06 (-0.13 to 0.25)
MF-R (N/kg)	16.68 ± 1.54	16.88 ± 1.67	16.83 ± 1.49	0.12 (-0.05 to 0.30)	0.10 (-0.10 to 0.29)	-0.03 (-0.22 to 0.16)
CON-L (N·s/kg)	2.05 ± 0.57	1.99 ± 0.22	1.98 ± 0.20	-0.14 (-0.32 to 0.04)	-0.16 (-0.36 to 0.03)	-0.05 (-0.24 to 0.14)
CON-R (N·s/kg)	2.10 ± 0.55	2.00 ± 0.29	2.05 ± 0.40	-0.23 (-0.40 to -0.05)	-0.10 (-0.30 to 0.09)	0.14 (-0.05 to 0.34)
ECC-L (N·s/kg)	0.50 ± 0.13	0.44 ± 0.09[a]	0.48 ± 0.14[c]	-0.54 (-0.72 to -0.36)	-0.15 (-0.34 to 0.05)	0.34 (0.15 to 0.53)
ECC-R (N·s/kg)	0.51 ± 0.11	0.46 ± 0.11[a]	0.48 ± 0.16[b]	-0.45 (-0.63 to -0.28)	-0.22 (-0.41 to -0.02)	0.15 (-0.05 to 0.34)

[a] = significantly different to U23 ($p < 0.01$); [b] = significantly different to U23 ($p < 0.05$); [c] = significantly different to U18 ($p < 0.01$); [d] = significantly different to U18 ($p < 0.05$).

CMJ = countermovement jump; MF = mean force; L = left; R = right; N/kg = Newtons per kilogram; N·s/kg = Newton seconds per kilogram; CON = concentric; ECC = eccentric; UCMJ = unilateral countermovement jump.