Effects of Pre-Season Strength Training on Bilateral and Unilateral Jump Performance, and the Bilateral Deficit in Premier League Academy Soccer Players

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Abstract

The aim of this study was to determine the effects of pre-season strength training on bilateral and unilateral jump performance and the bilateral deficit (BLD) in Premier League academy soccer players. Fourteen male academy players (age: 16.36 ± 0.50 years; body mass: 73.45 ± 8.43 kg; height: 1.80 ± 0.09 m) performed one upper body and one lower body strength session per week, for eight weeks. Bilateral and unilateral countermovement jumps (CMJ) were assessed pre and post-intervention with jump height, mean force, reactive strength index modified (RSI-Mod) and time to take-off reported for each test. In addition, the BLD was also computed for each metric. Results showed meaningful and significant increases in unilateral jump height on the left (g = 1.00; p = 0.02) and right (g = 0.77; p = 0.039) legs, and for the BLD for jump height (g = 0.67; p = 0.046). No other significant changes in jump performance were evident. Despite numerous non-significant changes in jump performance at the group level, individual analysis showed numerous players exhibited percentage improvements greater than the variance in the test (as depicted by the coefficient of variation), across all metrics. Thus, the results illustrate that a single lower body strength session per week is enough to elicit positive improvements in jump performance for all metrics when assessed on an individual basis, but only for unilateral jump height, when assessed at the group level. Significant increases were also evident for jump height BLD. Despite the majority of players exhibiting improvements in jump performance, some small reductions in performance were also evident. Given the requirement for soccer players to be competent during unilateral movement patterns, an increase in the BLD may be favourable, as it shows greater improvements in unilateral test scores compared to bilateral.

Key Words: Strength training; intervention; athletic performance.

Introduction

Soccer is a high-intensity, intermittent team sport, which requires the development of multiple athletic qualities in order to optimise physical performance. For example, soccer players have been shown to jump up to 15 times during competition (Nedelac et al. 2014), perform 168 accelerations and decelerations (Taylor et al. 2017) and seminal research from Bangsbo (1992) suggested players can change direction between 1200-1400 times per game. However, the one key physical attribute that underpins most others is strength (Suchomel et al. 2016). Furthermore, a recent meta-analysis showed that strength was the most commonly programmed physical component during training interventions aiming to reduce the risk of injury in female players (Crossley et al. 2020). When compared to matched controls, interventions that included strength training, significantly reduced the injury incidence ratio (IRR) for anterior cruciate ligament (IRR = 0.55 [0.32, 0.92]) and hamstring (IRR = 0.40 [0.17, 0.95]) injuries. Thus, with strength training critical for optimizing athletic performance and potentially reducing the risk of injury, it is clearly one form of training that all soccer players should be undertaking (Beato et al. 2021).

From a testing and monitoring perspective, jump tests are a common form of assessment to determine a soccer players' lower body jump capability, with previous researchers frequently employing countermovement jumps (CMJ) (Loturco et al. 2018; Loturco et al. 2019), squat jumps (SJ) (Kotzamanidis et al. 2005), drop jumps (DJ) (Gissis et al. 2006) and their associated unilateral versions (Bromley et al. 2018; Bishop et al. 2019; Bishop et al. 2019). Specifically, the CMJ appears to have been most commonly utilised, most likely because of its ease of implementation and time-efficient nature. Furthermore, the CMJ frequently shows high reliability in soccer players (Loturco et al. 2019; Stern et al. 2020) and ability to determine meaningful change post-competitive matches in metrics such as jump height and concentric impulse (Bishop et al. 2019). However, less information is currently available on changes in CMJ performance, using academy soccer players, specifically after strength training interventions. Stern et al. (2020) recently compared a 6-week bilateral vs. unilateral-biased strength and jump training program on multiple physical characteristics in elite academy soccer players. When considering the CMJ, both groups showed no significant changes in bilateral (1.63-3.12%) or unilateral CMJ height (3.49-9.84%). Similarly, Ronnestad et al. (2008) investigated the effects of the half squat exercise (two sessions a week for seven weeks) on various measures of physical performance in 21 Norwegian soccer players. When considering changes in jump performance, CMJ height showed no significant change (< 4%), whilst SJ height showed significant improvements (8.5%). Despite comparable results in bilateral CMJ height to that of Stern et al. (2020), this study was conducted with professional players, and only used a single exercise to try and induce positive adaptation. Thus, further studies which align to more common methods of programming (i.e., with multiple exercises) are warranted in elite academy soccer players. In addition, assessing changes solely in jump height, does not provide any indication of alterations to jump strategy, something which has been increasingly recognised as an important consideration for practitioners during the monitoring process (Gathercole et al. 2015; Gathercole et al. 2015; Bishop et al. 2019). Specifically, and when using the CMJ test, metrics such as impulse, reactive strength index modified (RSI-Mod) and contraction time have become increasingly prevalent in the literature (Bishop et al. 2018; Bishop et al. 2019; Bromley et al. 2018; Gathercole et al. 2015; Suchomel et al. 2014).

Another area often under-researched is the bilateral deficit (BLD). This refers to the notion that the sum values of left and right from unilateral tasks are greater than their bilateral counterpart (Nijem and Galpin, 2014). Previous research has shown the prevalence of the BLD across multiple tasks such as isokinetic dynamometry (Šarabon et al. 2020; Skarabot et al. 2016), leg press (Samozino et al. 2014; Janzen et al. 2006), and both CMJ and DJ tasks (Ascenzi et al. 2020; Bishop et al. 2019; Pain 2014). Previous research using associative analysis has shown conflicting results. For example, Ascenzi et al. (2020) showed no significant correlations between the BLD during the squat jump under different loads and linear and change of direction (COD) speed times. In contrast, Bishop et al. (2019) showed significant moderate correlations between CMJ height BLD and 505 times (r = -0.48 to -0.53) and CMJ concentric impulse BLD and 505 times (r = -0.51 to -0.64). It is important to note that these correlations are negative, indicating that a larger BLD percentage was associated with faster COD speed times. In essence, it may be advantageous to be comparably better on one leg than two; however, such research is associative in nature and thus, training intervention studies likely offer more robust evidence when aiming to determine the importance of the BLD.

Janzen et al. (2006) compared the effects of bilateral and unilateral strength training in post-menopausal women, with results showing the task-specific nature of training and its effects on the BLD. When considering the leg press and knee extension exercises, bilateral training improved both bilateral and unilateral strength measures, but with greater improvement seen bilaterally, resulting in a reduction in the BLD. In contrast, unilateral training showed similar improvements in both modalities; thus, little change occurred in the BLD. When considering a more athletic population, Gonzalo-Skok et al. (2017) compared 6-week bilateral and unilateral strength and power training interventions on a variety of physical performance measures (including the BLD) in elite youth Spanish basketball players. The BLD was calculated for power from bilateral and unilateral squat tasks, via a linear position transducer. Unilateral training caused an increase in the BLD from 24.8% to 36.8%, indicating greater improvements in unilateral squat power. In contrast, bilateral training cause only a small increase in the BLD from 23.1% to 27.0%, indicating similar improvements in both bilateral and unilateral squat power. Given the scarcity of training interventions and their effects on the BLD in soccer players, and the aforementioned conflicting evidence, further research investigating the effects of strength training on the BLD seems warranted.

Therefore the aims of the present study were twofold: 1) to examine the effect of an 8-week pre-season strength training intervention on bilateral and unilateral jump performance in elite academy soccer players, and 2) to determine the effect of said intervention on the BLD. It was hypothesized that significant improvements in bilateral and unilateral jump performance, and the BLD would be evident in 8-weeks.

Methods

Experimental Approach to the Problem

This study used a quasi-experiment design to determine the effectiveness of an 8-week strength training intervention (June to July 2020) on bilateral and unilateral jump performance and the BLD. Given the length of time where routine training and competition was interrupted due to the COVID-19 pandemic (approximately 3-months from March to May), this study employed 2 strength training sessions per week; one for the upper body and one for the lower body (see Table 1). It is worth noting that all players conducted resistance training throughout the lockdown period of the pandemic in the UK; however, this was entirely bodyweight in nature. Example exercises included: bilateral and unilateral squats, multi-directional lunges, ballistic jumps, and a variety of trunk strengthening exercises. Despite the lack of structured weight room training in the build-up to the intervention period, all players were familiar with testing protocols, which formed part of the routine fitness testing four times per season.

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

Participants

Fourteen elite male academy soccer players (age: 16.36 ± 0.50 years; body mass: 73.45 ± 8.43 kg; height: 1.80 ± 0.09 m) from the under-18 squad of a Category 1 Premier League soccer academy volunteered to participate in this study. All players had a minimum of four years competitive soccer experience and two years structured strength and conditioning training experience. Owing to the study being conducted during pre-season and after the initial period of a global pandemic, no major or minor injuries were recorded at the time of either testing period or in the preceding 3-month period. Written informed consent was provided by all parents or legal guardians and participants. This study was approved by the *[deleted for peer review]* research and ethics committee.

Procedures

Prior to data collection, all players completed a standardized warm up at both time points 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 bilateral and unilateral 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 players.

Bilateral and Unilateral Countermovement Jumps

For data collection, all jumps were performed on twin force platforms (ForceDecks, London, United Kingdom) operating at 1000 Hz. 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 jump height, mean (propulsive) force, RSI-Mod and time to take-off, with definitions for their quantification conducted in line with suggestions by Chavda et al. (2018) and McMahon 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). Mean force was defined as the average force output during the propulsive phase of the jump prior to take-off (Chavda et al. 2018; McMahon et al. 2018). RSI-Mod was calculated by dividing jump height by time to take-off (Suchomel et al. 2015). Time to take-off was defined as the duration from the initiation of the countermovement (detected once force had decreased by $\geq$ 20 Newtons [N] after a 1-2 second quiet standing period) to the moment of take-off (defined when force was $<$ 20 N). These metrics were chosen to provide an understanding of the outcome measure (jump height), the driver behind the outcome measure (mean force) and some indication of jump strategy (RSI-Mod and time to take-off). 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 then used for subsequent data analysis.

Training Intervention

Tables 2a and 2b provide the upper and lower body training sessions during the 8-week intervention, respectively. Given players' routine training schedule was interrupted in the build-up to pre-season, it was decided by the club staff that only one lower body session would be conducted in the weight room per week, in addition to one high load training session on the pitch. This decision was taken in an attempt to reduce large spikes in workload after coming back from minimal training during the first lockdown period of the COVID-19 pandemic. All sessions were supervised by an accredited strength and conditioning coach. From a soccer conditioning perspective, high, moderate and low volume sessions were determined from individual player match day data and defined in relation to high speed running distance (> 5.5 metres per second) as: > 80%, 40-60% and < 20%, respectively (Beato et al. 2020). Further to this, players performed technical drills in the same training sessions, although conditioning was always performed first, regardless of training day.

***** Insert Tables 2a and 2b about here *****

Statistical Analyses

All data were initially presented as means and standard deviations (SD) in Microsoft Excel and then later transferred to SPSS (Version 25.0, IBM, New York, USA) for subsequent analyses. Normality of the data was confirmed using the Shapiro-Wilk test ($p > 0.05$). The coefficient of variation (CV) and a two-way random intraclass correlation coefficient (ICC) with absolute agreement and 95% confidence intervals (CI) were used at both time points to report absolute and relative reliability, respectively. ICC values were interpreted in line with the lower 95% CI boundary suggestions by Koo and Li (2016) where: > 0.90 = excellent; 0.75-0.90 = good; 0.50-0.74 = moderate and < 0.50 = poor and CV values were considered acceptable if < 10% (Cormack et al. 2008).

Percentage change was reported for all metrics and subsequently compared to the pre-intervention CV value to determine whether changes in jump performance or the BLD were greater than the variance in the test; thus, providing an indication of whether true change occurred for each player. The BLD was calculated from the equation proposed by Rejc et al. (2010): 1- (bilateral/left + right))*100.

Paired samples *t*-tests were used to determine changes in jump performance or the BLD, with statistical significance set at $p < 0.05$. Hedges g effect sizes (ES) with 95% CI provided an understanding of practical significance and were interpreted in line with suggestions by Rhea (2004) where: < 0.25 = trivial; 0.25-0.50 = small; 0.51-1.0 = moderate and > 1.0 = large.

Results

Table 3 provides mean and SD data, absolute and relative reliability, and Hedges *g* ES data for bilateral and unilateral jump metrics at pre- and post-intervention. At the pre-intervention time point, relative reliability ranged from poor to excellent (ICC = 0.47-0.92), whilst all CV values were < 10%, with the exception of unilateral RSI-Mod (12.22-15.84%). At post-intervention, relative reliability ranged from moderate to excellent (ICC = 0.56-0.95) and all CV values were < 10%. Regarding group changes in jump performance, significant increases in unilateral jump height were evident for the left leg (g = 1.00 [0.34, 1.66]; p = 0.02), right leg (g = 0.77 [0.12, 1.41]; p = 0.039), and the BLD (g = 0.67 [0.03, 1.31]; p = 0.046). All other changes in bilateral and unilateral metrics were small (g range = -0.40 to 0.50).

Figures 1-4 provide individual player pre- and post-intervention bilateral and unilateral jump data. Players who showed percentage change greater than pre-intervention CV (and therefore, true change) are signified by a solid black line, whilst the dashed lines represent percentage change less than the pre-intervention CV. Finally, individual player BLD data has been presented in Figure 5 and highlights the metric-specific nature of the BLD, especially when viewing RSI-Mod.

***** Insert Table 3 about here *****

***** Insert Figures 1-5 about here *****

Discussion

The aims of the present study were to: 1) determine the effect of an 8-week pre-season strength training intervention on bilateral and unilateral jump performance in elite academy soccer players, and 2) determine the effect of said intervention on the BLD. Results showed that a single lower body strength session per week was sufficient to produce moderate to large improvements (g = 0.77-1.00) in unilateral jump height. As a consequence of these improvements, this in turn caused a moderate increase in the BLD for jump height (g = 0.67).

Although the majority of data showed acceptable absolute and relative reliability (Table 3), it is important to note that RSI-Mod exhibited elevated CV values unilaterally (12.22-15.84%), but only during pre-intervention testing. Given these values were noticeably higher than the CV values for all other unilateral jump metrics, it seems plausible to suggest that players may have exhibited multiple strategies during pre-testing for the unilateral CMJ, resulting in elevated test variability scores for RSI-Mod. Furthermore, given all other jump metrics showed acceptable CV scores, it seems that RSI-Mod may exhibit noticeably greater variability, which practitioners should be mindful of given the increase in recent years investigating this metric (McMahon et al. 2018; Suchomel et al. 2015). This is likely down to the fact that it is a ratio number (i.e., made up of two component parts). Recently researchers have highlighted the variable nature of ratio data (albeit in asymmetry) (Bishop et al. 2019; Bishop et al. 2020; Bishop et al. 2020), which typically shows that when two metrics are compounded to create a single value, the source of error gets magnified. However, the results of the current study would suggest that this only applied to RSI-Mod unilaterally. Furthermore, when using the CI for interpreting relative reliability data, time to take-off showed noticeably better reliability at post-intervention testing (Table 3). Thus, it is possible that additional test familiarisation may have improved the pre-testing ICC values and this is something practitioners should be mindful of before collecting their own jump testing data.

When considering changes in jump performance, the only significant improvements were noted in jump height, unilaterally on both limbs (g = 0.77-1.00). Fully understanding why greater improvements were seen unilaterally is challenging given the lower body intervention included both bilateral and unilateral exercises. However, it is important to remember the training intervention in the present study was focused on strength (as opposed to velocity through plyometrics or sprint training). Previous research has shown that movement velocity is slower during unilateral CMJ compared to bilateral CMJ (Cohen et al. 2020) because of the increased force production required per limb. This may in part help to explain why significant changes were shown for the unilateral, and not bilateral CMJ. Furthermore, additional research has highlighted that jump height (when tested using a bilateral CMJ) may not be an overly sensitive metric at detecting true change (Gathercole et al. 2015; Gathercole et al. 2015). In contrast, recent research has shown that when using the unilateral CMJ, jump height can show true change post-competition (Bishop et al. 2019; Kons et al. 2021) and slightly greater improvements than the bilateral CMJ (Stern et al. 2020) in elite academy soccer players. The challenge here is that to the authors' knowledge, there are a distinct lack of training interventions investigating the effect of strength training only on both bilateral and unilateral jump performance, using multiple metrics. However, in light of the meaningful change in unilateral jump height and comparable research showing this metric's ability to show true change in a comparable population (Bishop et al. 2019; Stern et al. 2020), it is suggested that jump height (when tested unilaterally) may be a viable metric during both the ongoing monitoring process and for assessing changes in jump performance.

In contrast, mean force, RSI-Mod and time to take-off showed no significant changes after the intervention. Mean force only showed relatively small percentage changes (4.90-6.41%), but RSI-Mod showed much larger improvements (6.08-14.17%). However, the SD for this percentage change in RSI-Mod was almost as high as the mean value for both bilateral (SD = 5.07%) and unilateral (SD = 10.07-12.49%) results, which indicates large within-group variation in the results. This is also the likely reason why statistically significant changes were not detected for this metric. Despite these non-significant changes, individual percentage change still showed numerous players with improvements greater than the variance in the test (CV). This highlights the need to assess data on an individual athlete basis, a concept becoming more commonplace in research studies (Bishop et al. 2018; Robertson et al. 2017). Time to take-off showed a different trend, with small negative percentage changes bilaterally (-8.17%) and unilaterally (-1.95 to -4.12%). Although not significant, these data show there was a trend for players to perform the countermovement part of the CMJ faster (more so bilaterally) and thus, enhance their contraction time.

When considering changes in the BLD, the only metric to show a significant increase was jump height (g = 0.67). Interestingly, Figure 5 shows the distribution of data for individual changes in BLD to be quite small, especially for mean force. However, RSI-Mod showed a different pattern, with individual player data spread over a much larger range and we believe there to be two key points here. Firstly, as shown by the elevated CV values, RSI-Mod appears to be a noisier metric than jump height, mean force and time to take-off, when assessed unilaterally. This in itself may partly explain why the spread of data is so much greater for this metric, when reporting the BLD. Second, both RSI-Mod and the BLD are ratio statistics. As previously mentioned, recent research has highlighted that ratio data is often quite variable (Bishop et al. 2020; Bishop et al. 2020) and in this particular instance, reporting BLD data for a metric like RSI-Mod, is essentially merging two ratio numbers together, which is almost certain to magnify any associated noise. As such, practitioners should be mindful of using ratio data, especially if the associated variability (noise) is high, which may preclude such data from being used to inform the decision-making process.

Despite the novelty of these findings, the present study has a couple of key limitations which should be acknowledged. First, we only reported changes in jump performance. Although reporting both bilateral and unilateral jump data (for multiple metrics) after training interventions is rare, the addition of other commonly used fitness parameters (e.g., linear and change of direction speed) would have been useful, given the sample used. Second, the present study used a convenience sample which was small in number. We aimed to somewhat overcome this issue by reporting individual athlete data (which we believe is synonymous with how data is used in professional sporting organisations). However, a larger sample would enable results to be inferred to a wider population. Thus, with a small sample and therefore, making it hard to infer these results to wider populations, practitioners may wish to employ a similar method of analysis (i.e., determining true change) with their own set of athletes to determine the effectiveness of their training interventions.

Practical Applications

Although somewhat anecdotal, it seems likely that a combination of bilateral and unilateral exercises is sensible when programming for soccer players, and these data show that such a combination is enough to elicit meaningful improvements in unilateral jump height from only a single lower body strength session per week. However, following the principle of specificity, coaches should also consider a blend of strength and ballistic jump or plyometric exercises to increase the chances of further improvements in jump performance, both bilaterally and unilaterally.

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Table 1. Weekly training schedule for the players.

Time of Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
AM (Pitch)	Soccer training (high load)	Soccer training (low load)	OFF	Soccer training (moderate load)	Soccer training (low load)	Pre-season fixture	OFF
PM (Gym)	Gym (upper body)	Gym (lower body)	OFF	OFF	OFF	OFF	OFF

Table 2a. 8-week pre-season lower-body strength training program (performed on Mondays).

Exercise	Sets	Repetitions	Load	Rest
A1. Bench Press	3	4-6	80-88% 1RM	4 minutes
B1. Wide Grip Pull Ups	3	4-6	BW*	4 minutes
C1. DB Military Press	3	6	As much as optimal	3 minutes
C2. DB Single Arm Row	3	6 each side	technique allowed	3 minutes

*RM = repetition maximum; DB = dumbbells; BW = bodyweight; * additional load used via a weight vest if required.*

Table 2b. 8-week pre-season lower-body strength training program (performed on Tuesdays).

Exercise	Sets	Repetitions	Load	Rest
A1. Trap Bar Deadlift	3	4-6	80-88% 1RM	4 minutes
B1. Romanian Deadlift	3	4-6	80-88% 1RM	4 minutes
C1. DB Split Squat	3	6 each side	As much as optimal	3 minutes
C2. DB Lateral Lunge	3	6 each side	technique allowed	3 minutes

RM = repetition maximum; DB = dumbbells.

Table 3. Mean and standard deviation (SD) data, absolute and relative reliability and Hedges *g* effect sizes between pre to post-intervention.

Jump Variable	**Pre-Intervention**			**Post-Intervention**			*Hedges g*
	Mean ± SD	*CV (%)*	*ICC (95% CI)*	*Mean ± SD*	*CV (%)*	*ICC (95% CI)*	
Jump Height (cm):							
Bilateral	37.18 ± 3.10	2.99	0.87 (0.74, 0.95)	38.90 ± 3.62	2.85	0.92 (0.83, 0.97)	0.50 (-0.14, 1.13)
Left	20.69 ± 2.50	6.28	0.75 (0.55, 0.88)	22.95 ± 1.83	4.85	0.77 (0.56, 0.90)	**1.00 (0.34, 1.66)**
Right	20.37 ± 2.38	7.51	0.78 (0.58, 0.90)	22.29 ± 2.48	6.26	0.88 (0.76, 0.95)	**0.77 (0.12, 1.41)**
Mean Force (N):							
Bilateral	1469.12 ± 232.59	3.20	0.95 (0.88, 0.98)	1543.64 ± 268.10	3.45	0.96 (0.91, 0.98)	0.29 (-0.34, 0.91)
Left	1201.05 ± 183.51	4.64	0.85 (0.70, 0.94)	1279.40 ± 215.25	4.19	0.92 (0.83, 0.97)	0.38 (-0.25, 1.01)
Right	1180.98 ± 183.49	5.04	0.92 (0.83, 0.97)	1253.90 ± 216.57	3.56	0.98 (0.95, 0.99)	0.35 (-0.27, 0.98)
RSI-Mod:							
Bilateral	0.47 ± 0.13	6.24	0.96 (0.92, 0.99)	0.49 ± 0.12	6.36	0.93 (0.85, 0.97)	0.16 (-0.47, 0.78)
Left	0.26 ± 0.07	12.22	0.72 (0.49, 0.86)	0.29 ± 0.08	8.36	0.91 (0.81, 0.96)	0.39 (-0.24, 1.01)
Right	0.26 ± 0.06	15.84	0.76 (0.55, 0.89)	0.29 ± 0.07	9.88	0.94 (0.86, 0.97)	0.45 (-0.18, 1.08)
TTTO (s):							
Bilateral	0.83 ± 0.18	4.70	0.95 (0.89, 0.98)	0.76 ± 0.16	3.91	0.98 (0.95, 0.99)	-0.40 (-1.03, 0.23)
Left	0.90 ± 0.24	7.71	0.81 (0.63, 0.92)	0.85 ± 0.19	4.82	0.95 (0.90, 0.98)	-0.22 (-0.85, 0.40)
Right	0.87 ± 0.16	8.93	0.71 (0.47, 0.87)	0.85 ± 0.17	4.37	0.94 (0.86, 0.97)	-0.12 (-0.74, 0.50)

CV = coefficient of variation; ICC = intraclass correlation coefficient; CI = confidence intervals; cm = centimetres; N = Newtons; RSI-Mod = reactive strength index modified; TTTO = time to take-off; s = seconds.

N.B: bold effect size data indicates statistically significant change in jump performance post-intervention.

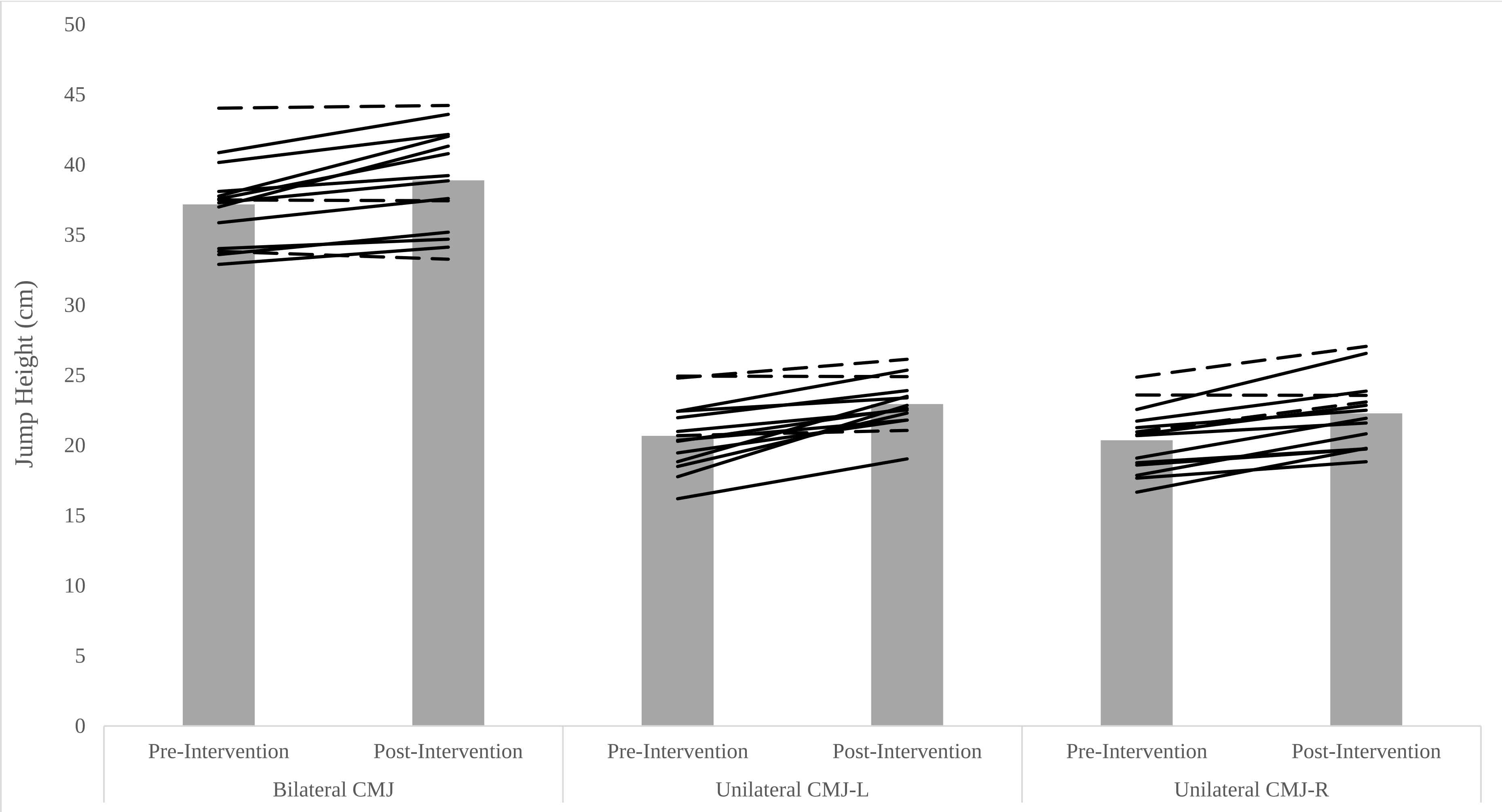

Figure 1. Mean and individual jump height data for bilateral and unilateral (left and right) countermovement jumps. N.B: solid lines indicate a % change > pre-intervention CV; dashed lines indicate % change < pre-intervention CV.

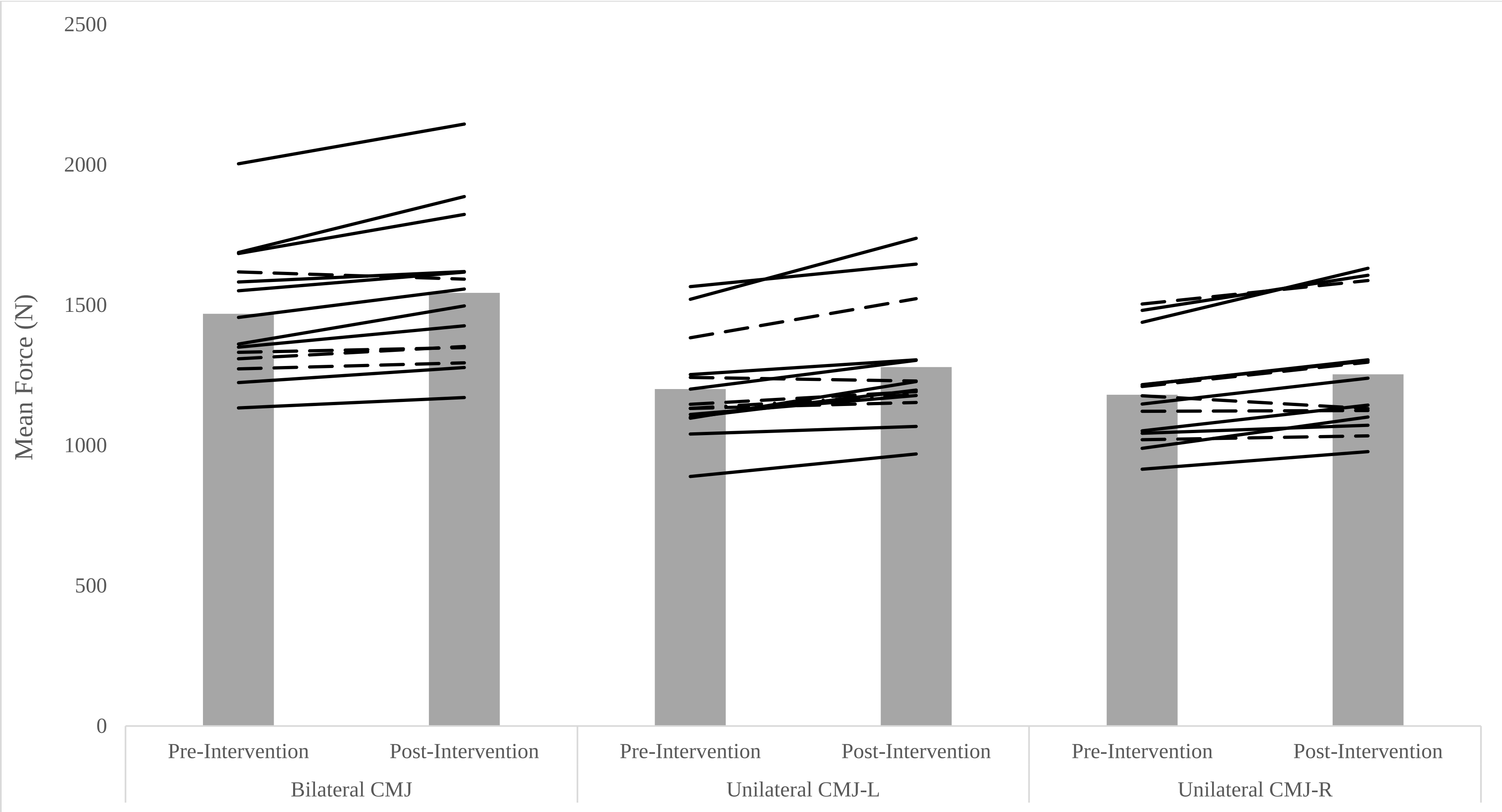

Figure 2. Mean and individual mean force data for bilateral and unilateral (left and right) countermovement jumps. N.B: solid lines indicate a % change > pre-intervention CV; dashed lines indicate % change < pre-intervention CV.

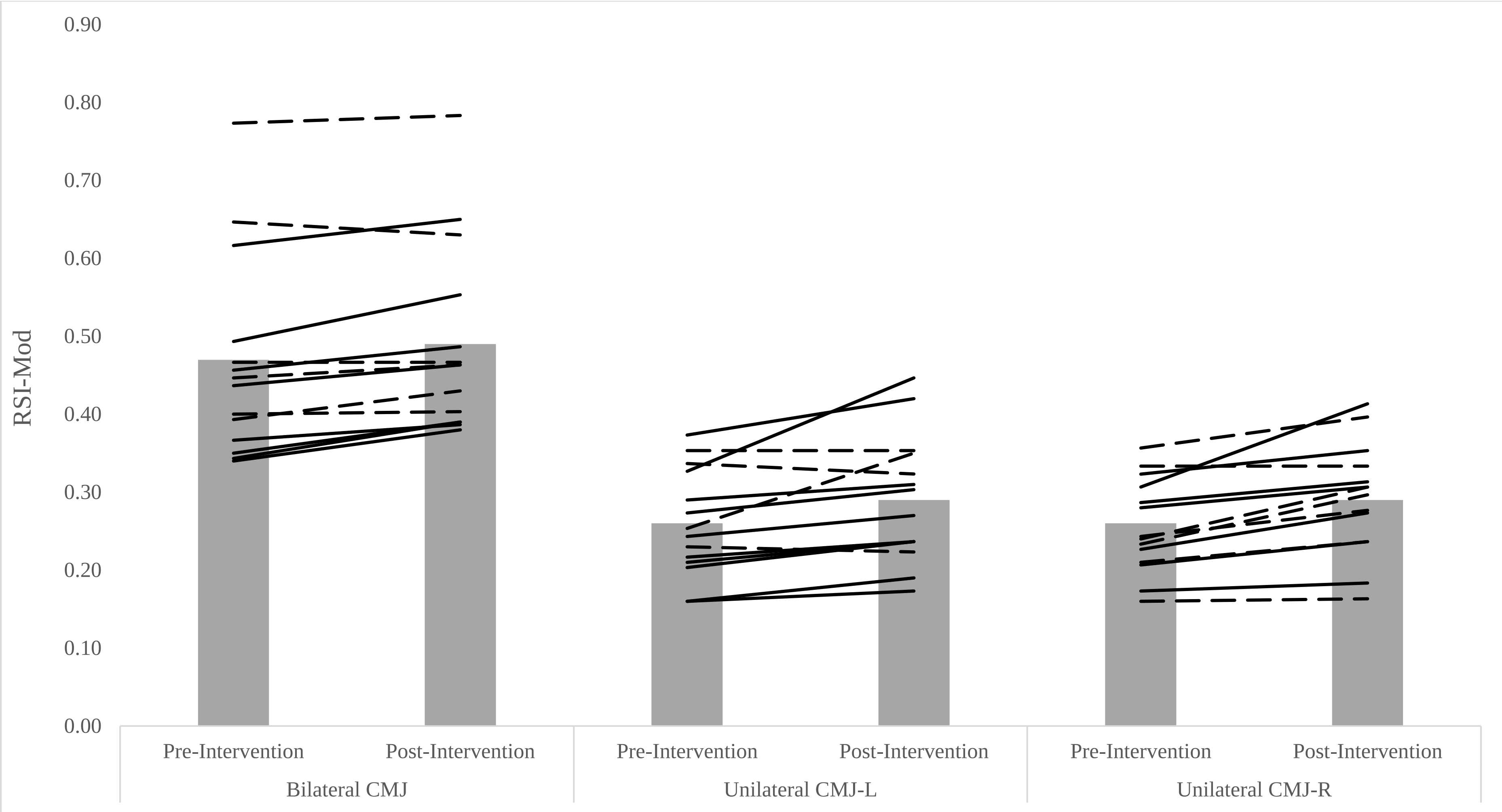

Figure 3. Mean and individual reactive strength index modified data for bilateral and unilateral (left and right) countermovement jumps. N.B: solid lines indicate a % change > pre-intervention CV; dashed lines indicate % change < pre-intervention CV.

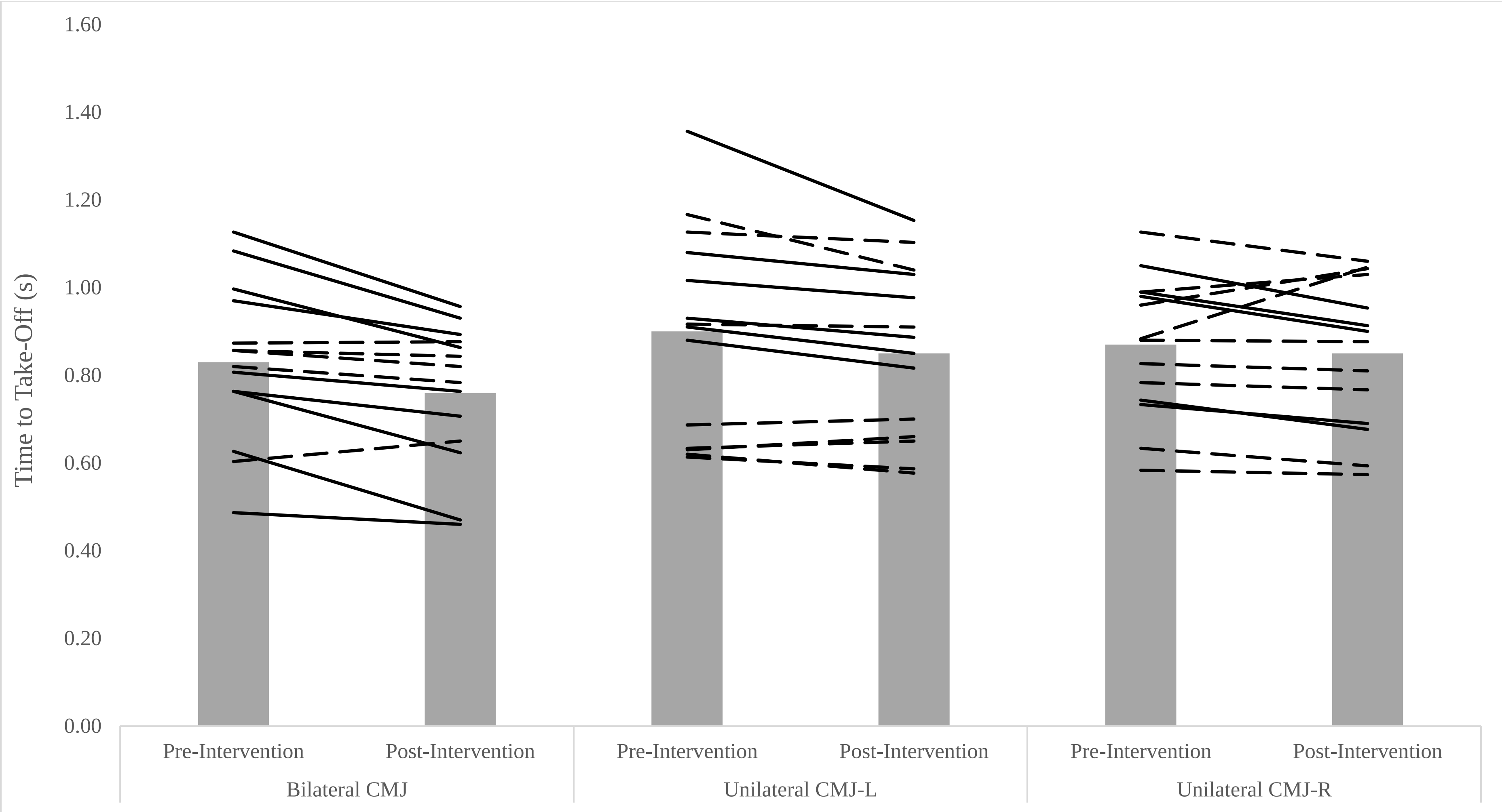

Figure 4. Mean and individual time to take-off data for bilateral and unilateral (left and right) countermovement jumps. N.B: solid lines indicate a % change > pre-intervention CV; dashed lines indicate % change < pre-intervention CV.

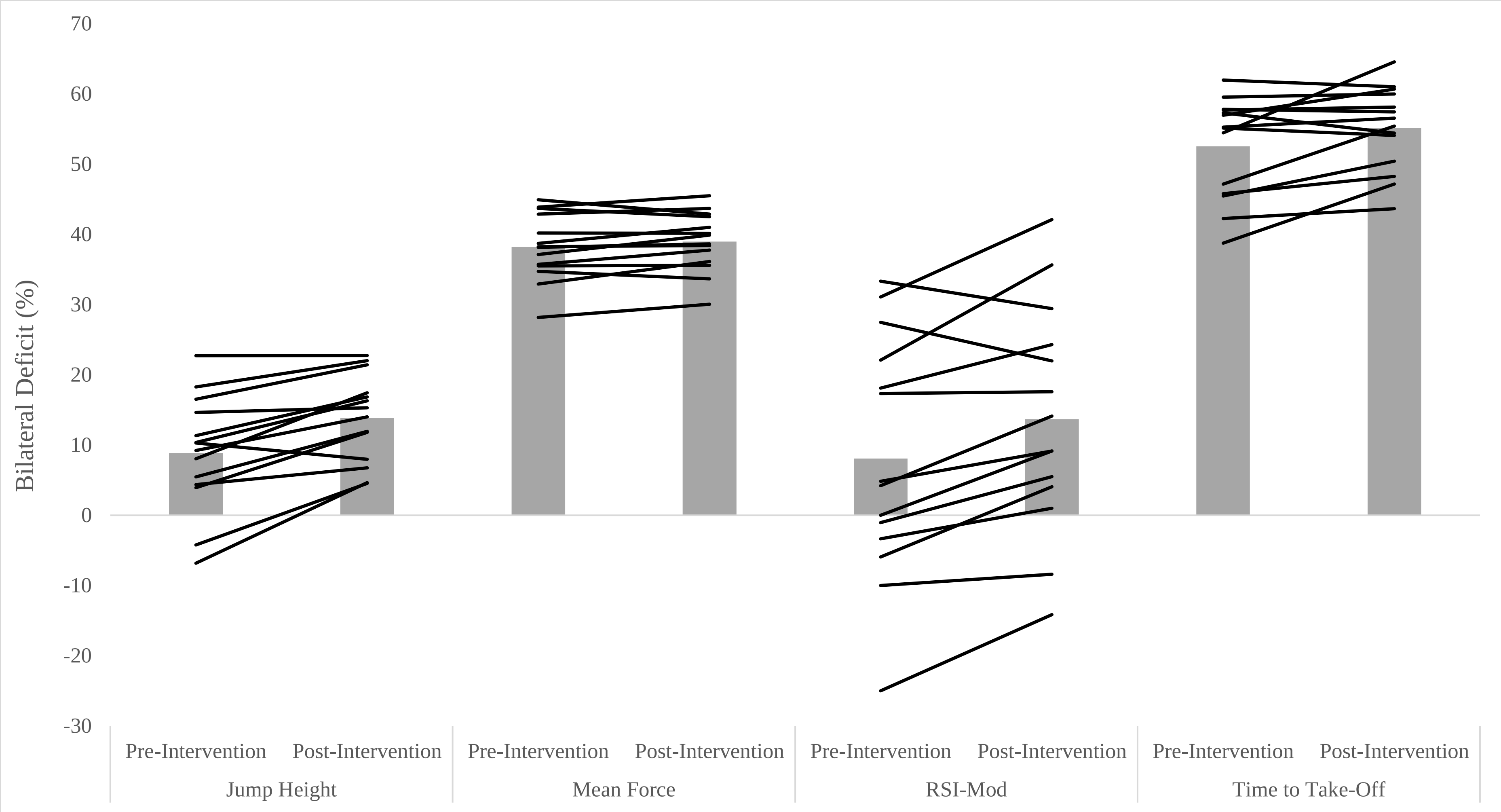

Figure 5. Mean and individual bilateral deficit data pre- and post-intervention for all four jump metrics.