Seasonal Variation of Physical Performance, Bilateral Deficit and Inter-limb Asymmetry in Elite Academy Soccer Players: Which Metrics are Sensitive to Change?

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Abstract

This study aimed to report seasonal variations for: 1) physical performance, 2) inter-limb asymmetry and, 3) BLD data over the course of a competitive soccer season, and determine which metrics are sensitive to change. This study used a repeated measures observational design for 19 under-20 elite academy soccer players (age: 17.58 ± 0.61 years; height: 1.81 ± 0.09 m; body mass: 74.36 ± 7.58 kg), who conducted bilateral and single leg countermovement jumps (CMJ and SLCMJ), linear speed (5, 10, 20 and 30-m) and 505 change of direction (COD) speed tests, at pre, mid and end of season time points. For jump tests, jump height, reactive strength index modified (RSI-Mod), time to take-off and countermovement depth metrics were monitored, with inter-limb asymmetry and the bilateral deficit (BLD) also calculated for each. Significant improvements ($p < 0.05$) in performance were evident in all fitness tests: CMJ (ES: 0.61 to 1.03), SLCMJ (ES: 0.60 to 2.25), linear speed (ES: -0.54 to -1.96) and COD speed (ES: -0.68 to -1.14). Significant reductions in asymmetry (ES: -0.68 to -1.07) and significant increases in the BLD (ES: 1.15 to 1.57) were also evident throughout the season. Additionally, Kappa coefficients were used to determine consistency in limb dominance throughout the season, but only poor to fair levels of agreement (K: -0.17 to 0.37) were evident, highlighting the fluctuating nature of limb dominance throughout the season. Despite all tests exhibiting meaningful change, the SLCMJ and linear speed showed the most frequent and largest differences in performance, highlighting their usefulness in the ongoing monitoring process of physical capacities in elite male academy players across a competitive soccer season.

Key Words: Jumping; Change of Direction Speed; Sprinting; Monitoring.

Introduction

Soccer is a high-intensity, intermittent sport which requires players to optimize multiple components of physical fitness. For example, literature has shown that soccer players can perform up to 168 high-intensity actions (e.g., acceleration, sprint and deceleration), (35), up to 15 maximal effort jumps (30) and even change direction over a 1000 times (2), all during a single competitive match. Given the large volume of competitive matches in a season, not to mention the additional physical demands from training, players need to be well conditioned to perform repeated explosive and powerful movements (i.e., sprinting, jumping and changing direction). Consequently, it is no surprise that fitness testing batteries in soccer often include: jump, sprint and change of direction (COD) speed testing (3,6,7,23,27).

Whilst the volume of published literature in soccer is large, longitudinal data over the course of a season is less common for these physical capacities. Where jump testing is concerned, Haugen (23) showed mean CMJ height of 37.4 ± 4.0 cm for pre-season, 38.1 ± 4.0 cm in-season, and 38.6 ± 3.9 cm in the off-season, with significant differences evident between pre-season and off-season periods in 44 Norwegian professional soccer players. Caldwell and Peters, (15) reported seasonal variation data for CMJ height in a male semi-professional soccer team (n = 13), testing at 5 stages over a 12-month period. Results were reported at the end of one season (57 ± 4.0 cm), start of the following pre-season (54 ± 3.2 cm), end of pre-season (56 ± 3.7 cm), middle of the season (57 ± 3.4 cm) and end of the season (57 ± 3.4 cm). Data were analysed by comparing the results at one time point to the results of the previous one, with significant changes noted between all-time points, except the final two (i.e., middle to end of season). These data provide some evidence that soccer players are likely to improve their jump performance throughout the season, highlighting the importance of the continued monitoring process.

When considering seasonal variation of linear and COD speed, Haugen (23) reported significant improvements in both 20 and 40-m sprint times in Norwegian professional players. Specifically, 20-m times started at 2.82 ± 0.09 s and improved to 2.80 ± 0.09 s and 2.77 ± 0.08 s, respectively, representing a continual and statistically significant improvement as the season progressed. The 40-m sprint also showed the same trend, with times statistically improving from 5.15 ± 0.17 s in pre-season to 5.11 ± 0.18 s and 5.07 ± 0.15 s in mid-season and end of season, respectively. Caldwell and Peters, (15) also reported seasonal variation data (as previously described) for 15-m sprint and the Illinois agility tests. For the 15-m test, sprint times were across the five time points were reported as follows: 2.43 ± 0.09, 2.51 ± 0.10, 2.49 ± 0.10, 2.44 ± 0.10 and 2.43 ± 0.08, with statistically significant changes evident between all time points except the last one. For the Illinois test, results were: 14.73 ± 0.37, 14.97 ± 0.38, 14.76 ± 0.38, 14.68 ± 0.34 and 14.63 ± 0.37, with statistically significant changes evident between all time points except the last two. Although these data indicate that meaningful changes occur in linear and COD speed throughout the season, and therefore a need to also monitor these physical capacities, the evidence does not appear entirely as conclusive as the seasonal variation data for jump testing.

An additional area of research which has seen growing interest in recent years is that of ratio data such as inter-limb asymmetry (8,10,12,20,26,28) and the bilateral deficit (BLD) (1,4,5,33). However, much of the literature has been conducted at single time points and does not provide an understanding of how these data fluctuate throughout a competitive season (11). Bishop et al. (8) used the single leg countermovement jump (SLCMJ) and single leg drop jump (SLDJ) tests to report inter-limb asymmetry at pre, mid and end of season, in elite academy soccer players. Results showed that the magnitude of asymmetry remained reasonably consistent throughout the season, with only trivial to small effect size (ES) changes for the SLCMJ (ES: -0.43 to 0.05) and the SLDJ (ES: -0.18 to 0.41). For the direction of asymmetry, results showed highly variable levels of agreement for both tests, with Kappa values ranging from poor to substantial for both the SLCMJ (Kappa: -0.06 to 0.77) and SLDJ (Kappa: -0.10 to 0.78) tests (8). These data highlighted the importance of monitoring the direction of asymmetry (i.e., consistency in limb dominance), in addition to the magnitude of imbalance. Whilst comparable data exists over a competitive season in professional cricket athletes (14), to the authors' knowledge, additional seasonal variation data for inter-limb asymmetry in soccer players does not exist. Equally, where the BLD is concerned, Bishop et al. (4) recently reported changes in jump height, mean force, reactive strength index modified (RSI-Mod) and time to take-off metrics, after an 8-week pre-season strength training intervention. Results showed that jump height was the only BLD metric to exhibit significant change (ES: 0.67). Despite these data, and to the best of the authors' knowledge, longitudinal BLD data over the course of a competitive season does not appear to exist. The relevance of this is that previous research has shown that both inter-limb asymmetry and the BLD are associated with reduced physical performance in soccer players (4,6,13) and thus, may be of interest to practitioners as part of the ongoing monitoring process throughout a competitive season.

Therefore, the aims of the present study were to report seasonal variations for: 1) physical performance, 2) inter-limb asymmetry and, 3) BLD data over the course of a competitive soccer season, and determine which metrics are sensitive to change.

Methods

Experimental Approach to the Problem

This study used an observational, repeated measures design during the 2020-2021 soccer season, for the under-20 age group of academy players at a Premier League soccer club. Routine fitness testing was undertaken at 3 time points: two weeks into pre-season (July), mid-season (December) and at the end of season (May), and consisted of bilateral CMJ, SLCMJ, 30-m sprint testing (with splits recorded at 5, 10 and 20-m) and the 505 COD speed test. Initial testing was undertaken two weeks after the start of pre-season to reduce the risk of possible injuries (e.g., to the hamstrings during maximal sprinting) and in an attempt to ensure that initial fitness testing scores were indicative of a true maximal effort (owing to player confidence during the testing process). To better contextualize the observed changes in physical performance, we have provided an example overview of the periodization of training (Table 1) and the strength and power training (Table 2) conducted throughout the season.

***** Insert Tables 1-2 about here *****

Subjects

Nineteen under-20 academy male soccer players (age: 17.58 ± 0.61 years; height: 1.81 ± 0.09 m; body mass: 74.36 ± 7.58 kg – data recorded during pre-season) from a Category 1 academy in the Premier League, volunteered to participate in this study. A priori power analysis using G*Power (Version 3.1, University of Dusseldorf, Germany) identified that when using a within factors, repeated measures ANOVA, a sample of 15 was required in order to fulfil a statistical power of 0.8, a type 1 alpha level of 0.05 and an effect size of 0.3. All players had been playing in an academy setting of a professional soccer club for a minimum of five years, with a minimum of four years of structured strength and conditioning training experience. In line with comparable research (8), players were required to be injury-free at the time testing and in the preceding four weeks prior to each test session. Written informed consent was provided from all subjects (and their guardians for any player under the age of 18), and each player was also cleared to participate in testing by the club's medical department. Ethical approval was provided by the *[deleted for peer review]* research and ethics committee.

Procedures

All players performed a standardized warm-up at each time point, consisting of 5-minutes slow jogging and a set of 1 x 10 repetitions of dynamic stretches (e.g., multiplanar lunges, inchworms, spidermans and bodyweight squats). Following this, three practice trials for each test was given at 60, 80 and 100% of perceived maximal effort, prior to the start of data collection. Testing was always conducted in a single day at each time point, in the following order: CMJ, SLCMJ, 30-m sprint and 505. Five minutes of rest was provided between the last practice trial and data collection procedures, with three trials completed for each test and an average of all trials used for subsequent data analysis. For jump tests, 90-seconds of rest was provided between trials and five minutes of rest between tests. For sprint and COD tests, three minutes of rest was provided between trials and five minutes between tests.

Bilateral and Single Leg Countermovement Jumps

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, RSI-Mod, time to take-off and countermovement depth, with definitions for their quantification conducted in line with suggestions by Chavda et al. (16) and McMahon et al. (29). 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). RSI-Mod was calculated by dividing jump height by time to take-off (34). Time to take-off was defined as the duration from the initiation of the countermovement (detected once force had decreased by ≥ 20 Newtons [N] after a 1-2 second quiet standing period) to the moment of take-off (defined when force was < 20 N). Countermovement depth was defined as the minimum displacement of the centre of mass prior to take-off. These metrics were chosen to provide a concurrent understanding of the outcome measure (jump height) and some indication of jump strategy (remaining metrics).

Calculation of Inter-limb Asymmetry and the Bilateral Deficit

Mean inter-limb asymmetries were computed from jump tests 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 (9). In order to determine the direction of asymmetry (which provided an indication of limb dominance), an 'IF function' was added on to the end of the formula in Microsoft Excel: *IF(left<right,1,-1), which ensured that the magnitude of asymmetry was not altered, when different limbs performed superior (8,14). The BLD was calculated from the equation proposed by Rejc et al. (32): 1- (bilateral/left + right))*100.

Linear Speed

Dual beam electronic timing gates (Brower Timing Systems, Draper, UT) were positioned at 0, 5, 10, 20 and 30-m, at a height of 1-m, enabling athlete's acceleration and top-speed ability to be measured. Athletes started the test in a staggered 2-point stance with toes positioned 30 cm behind the start line so as to not break the beam of the timing gates before the initiation of the test. When ready, subjects sprinted through the timing gates as fast as they could, allowing time to be recorded to the nearest 100th of a second. Testing was performed on an indoor 4G soccer pitch and players performed sprints and COD tests in their own football boots.

Change of Direction Speed

A distance of 15-m was measured with electronic timing gates (Brower Timing Systems) positioned at the 10-m mark and the 15-m point marked out by an existing white line on the pitch, to ensure that players could clearly see the turning point, as they approached. Players sprinted 15-m and then performed a 180° turn off both the right and left legs, with a total of three trials completed on each leg. The time started when players broke the electronic beam at the 10-m mark and after turning 180°, subsequently sprinted back through the timing gates to complete a recorded distance of 10-m. Trials were only deemed successful if the players' foot fully crossed the line during the turn.

Statistical Analyses

All data were initially recorded as means and standard deviation (SD) in Microsoft Excel and later transferred to SPSS (version 25.0; SPSS, Inc., Armonk, NY, USA). Normality was assessed using the Shapiro-Wilk test and showed asymmetry data to be non-normally distributed ($p < 0.05$), whilst test scores were normally distributed. Within-session reliability data was computed at each time point using an average measures two-way random intraclass correlation coefficient (ICC) with absolute agreement and 95% confidence intervals, and the coefficient of variation (CV). Interpretation of ICC values was in accordance with previous research by Koo and Li (25) where values > 0.9 = excellent, 0.75-0.9 = good, 0.5-0.75 = moderate, and < 0.5 = poor, and CV values < 10% considered acceptable (18).

A repeated measures ANOVA was conducted to determine differences in test scores and a Friedmans ANOVA to determine differences in asymmetry and BLD scores between time points, with statistical significance set at $p < 0.05$. The magnitude of change was also calculated between time points using Hedges *g* effect sizes (ES) with 95% confidence intervals and interpreted in line with suggestions by Hopkins et al. (24) where: < 0.20 = trivial; 0.20-0.60 = small; 0.61-1.20 = moderate; 1.21-2.0 = large; 2.0-4.0 = very large; and > 4.0 = near perfect. Finally, Kappa coefficients were calculated to determine the levels of agreement for how consistently an asymmetry favoured the same side (direction of asymmetry) when comparing the different time points measured. This method was chosen because the Kappa coefficient describes the proportion of agreement between two methods after any agreement by chance has been removed (17). Kappa values were interpreted in line with suggestions from Viera and Garrett (36), where: ≤ 0 = poor, 0.01-0.20 = slight, 0.21-0.40 = fair, 0.41-0.60 = moderate, 0.61-0.80 = substantial, 0.81-0.99 = almost perfect and 1 = perfect.

Results

Table 3 shows absolute and relative reliability data using the CV and ICC, respectively. All CV values were < 10% indicating acceptable variability throughout the season and ICC values ranged from moderate to excellent at each time point, with the SLCMJ and linear speed tests showing the lowest ICC values.

Table 4 shows mean and SD values for each test throughout the season, accompanied by Hedges *g* data, with significant change signified by bold ES values. In summary, jump height was the only metric during the CMJ to show significant increases (ES: 0.61 to 1.03), whilst the SLCMJ reported more meaningful differences, especially for jump height (ES: 0.73 to 2.25), RSI-Mod (ES: 0.60 to 0.90) and countermovement depth (ES: 0.62 to 1.03). Linear speed testing showed consistent and large improvements throughout the season, for all distances: 5 m (ES: -0.98 to -1.96), 10 m (ES: -0.65 to -1.96), 20 m (ES: -0.71 to -1.24) and 30 m (ES: -0.54 to -1.15).

Table 5 shows mean and SD values for inter-limb asymmetry and BLD data, accompanied by Hedges *g* data. Significant reductions in asymmetry were evident for jump height (ES: -1.05 to -1.07), time to take-off (ES: -0.93 to -1.02) and countermovement depth (ES: -0.68 to -0.98), but not RSI-Mod. For the BLD, the only metric to show significant change (increase) across the season was jump height (ES: 1.15 to 1.57).

Table 6 shows Kappa coefficients for the direction of asymmetry throughout the season. Levels of agreement for jump height were slight to fair (K range: 0.15 to 0.37), slight to fair for RSI-Mod (K range: 0.14 to 0.37), poor to fair for time to take-off (K range: -0.17 to 0.37) and poor to slight for countermovement depth (K range: -0.13 to 0.19). Owing to the variable nature of ratio data, Figures 1 and 2 provide individual asymmetry and BLD data for each metric.

***** Insert Tables 3-6 about here *****

***** Insert Figures 1-2 about here *****

Discussion

The aim of the present study were to report seasonal variations for: 1) physical performance, 2) inter-limb asymmetry and, 3) BLD data over the course of a competitive soccer season, and determine which metrics are sensitive to change. Results showed all tests exhibited some meaningful change across the season, but with the largest and most frequent differences seen in the SLCMJ and linear speed tests. The magnitude of asymmetry showed meaningful changes more frequently than the BLD, which only showed meaningful change for jump height. Finally, the direction of asymmetry showed only poor to fair levels of agreement for all metrics.

Table 4 shows the mean, SD and ES values for physical performance tests over the competitive season. When considering the bilateral CMJ, the only metric to show significant change across the season was jump height. This is somewhat surprising given previous research has outlined that strategy metrics (e.g., impulse) are more sensitive to true change after intense exercise compared to outcome measures such as jump height (21,22). However, in this instance, it appears that RSI-Mod, time to take-off and countermovement depth are not overly sensitive to change throughout the season, which may indicate that alternative strategy metrics may need to be considered bilaterally. In contrast, the SLCMJ showed more frequent significant changes throughout the season for all metrics, except time to take-off. In addition, jump height actually showed the greatest magnitude of change out of all jump metrics, with very large improvements from pre to end of season (ES: 2.24 to 2.25). Furthermore, previous literature has also shown that jump height is sensitive to meaningful change after intense exercise, but when performed unilaterally (4,10). Thus, despite previous suggested limitations of jump height (21,22), the results in the present study do not support this suggestion. Therefore, given these findings and the comparable results from previous research (4,10), it is our suggestion that practitioners working in soccer consider implementing the unilateral CMJ during their routine testing and monitoring throughout the season. Given the requirement for unilateral movement competency in soccer (e.g., kicking, jumping and cutting) (30), this seems like a useful suggestion for practitioners; even for those who have limited budgets and cannot afford force platforms.

For linear speed, significant changes were evident between all time points for all distances, expect 20 and 30-m at the mid to end of season comparison. Previous research has shown that linear speed performance shows continued improvement throughout the season (23), which is likely down to improved physical fitness as the season progresses, especially when pre-season scores have also been shown to be considerably worse to previous season's end of season data

(15). Furthermore, recent research showed that the 10-m sprint was the most sensitive test at exhibiting meaningful change in seasonal variation of physical fitness of professional cricket athletes (14). Although a different sport, it is interesting to see that sprint testing appears to show significant change more consistently than jump testing in both soccer and cricket athletes. Given linear speed tests are a common inclusion in fitness testing batteries (3,6,7,23,31), this reinforces their value as part of the continued monitoring process in elite academy soccer players. For the 505 test, the greatest improvements in time were evident in the second half of the season, as represented by no significant changes from pre to mid-season. Interestingly, larger improvements were seen on the right leg, which may possibly be related to 14 out of 19 players (74%) being right footed in the current population, indicating superior performance on the dominant limb; which is not uncommon in sport (37). In addition, given the inherent differences between limbs in time improvements over the season (i.e., left leg ES = -0.68; right leg ES = -1.14), this highlights the importance of coaching COD actions, specific to each limb, especially when technique modifications can be so easily implemented in day-to-day coaching environments (19).

Table 5 shows the mean, SD and ES values for inter-limb asymmetry and the BLD over the competitive season. For asymmetry, and somewhat surprisingly, significant changes in the magnitude were evident for all metrics, except RSI-Mod, which is largely in contrast to previous longitudinal asymmetry monitoring studies, which have reported trivial to small changes across the season (8,10). Of note as well, all meaningful changes in asymmetry were reductions (i.e., higher levels of symmetry), which when coupled with the aforementioned improvements in unilateral jump performance (Table 2), can be considered a positive finding in the present study. This is supported by recent studies reporting associations between larger asymmetries and reduced physical performance in soccer players (6,13). Where RSI-Mod is concerned, it is not surprising that this metric showed no significant changes in asymmetry because it is a ratio metric in itself. Simply put, ratio data such as asymmetry have been acknowledged as quite noisy (8,10) and when combined with another ratio metric (i.e., RSI-Mod), this magnifies the within-group variability. Consequently, this can preclude any significant differences from being evident between time points, and has been shown in previous asymmetry research over a competitive season in academy soccer players previously (8). With these results in mind, we suggest that practitioners consider not using two combined ratio metrics (i.e., asymmetry and RSI-Mod) during their routine monitoring processes. Equally, given that unilateral jump height showed significant changes throughout the season, it somewhat stands to reason that jump height asymmetry also showed the largest changes of any asymmetry metric (Table 5). Previous research has shown jump height asymmetry to exhibit meaningful changes after intense exercise (10) and to be associated with reduced physical performance (6,13). Thus, we suggest that jump height asymmetry (in particular) should be monitored alongside the raw jump height scores. Furthermore, if practitioners aim to ensure that there are no major deficits in capacity between limbs (i.e., in this instance, jump height), then this is likely to have a knock-on effect of reducing inter-limb asymmetry values too (28).

For the BLD, jump height was the only metric to show meaningful differences across the season (ES: 1.15 to 1.57). Given how this metric is calculated, it is important to note that any change in the BLD is a consequence of changes in the raw jump data. Thus, and as alluded to earlier, because unilateral jump height showed greater changes than bilateral CMJ height across the season (Table 2), it stands to reason that the BLD increased significantly for this metric. Also of note, and although a different study design, jump height was the only metric to exhibit significant changes for the BLD in a recent 8-week strength training intervention in academy soccer players (4). Figure 2 also provides a clear illustration of this on an individual basis. For example, when comparing jump height vs. time to take-off, individual data shows progressive increases in the BLD for jump height, for almost all players. In contrast, BLD data for time to take-off appears to be more stable, as represented by the magnitude of the bars for each player visually appearing similar across the season. Also of note, there were a few instances where a bilateral facilitation was present across metrics (as represented by the negative bars on Figure 2). However, each time this occurs, there is a transition towards either a smaller bilateral facilitation or a deficit as the season went on. Once again. This is indicative of superior improvements in unilateral jump performance (compared to bilateral) as the season progressed.

Table 6 shows Kappa coefficients which report levels of agreement for the direction of asymmetry, over the competitive season. These data are in agreement with previous studies reporting season-long monitoring of the direction of asymmetry (8,14), where Kappa values were typically quite low (i.e., < 0.4) and in many instances, actually < 0. This form of analysis assesses the consistency in limb dominance characteristics between time points, and shows that it is rare for the same limb to perform superior between time points. Visually, this is again depicted clearly in Figure 1, which clearly shows that many players often exhibit right leg dominance at one time point, only to show left leg dominance at the following time point. For example, when assessing individual data for jump height asymmetry (top left in Figure 1), athlete 9 shows a 5.33% magnitude of asymmetry favouring the right leg at pre-season, but an

8.82% magnitude of asymmetry favouring the left leg in mid-season. If only absolute asymmetry values were monitored (i.e., all positive values), this would represent a small increase in imbalance. However, given the change in limb dominance here, this isn't strictly an increase in asymmetry of ~3.5%; rather, it is more like a ~14% shift in the imbalance. Thus, such examples are clear evidence of why both the magnitude and direction of asymmetry should be monitored by practitioners, throughout a competitive season. Whilst similar results have been shown in preceding asymmetry research (8,12,14), one study has also shown that such fluctuations in limb dominance are not associated with reduced in-match performance such as high-speed running or total distance covered (10). However, the implications of these fluctuations in limb dominance and whether they may increase the risk of injury in soccer players needs further investigation.

There are a couple of limitations that should be acknowledged. Firstly, although not under-powered, the sample size in the present study was still relatively small – which is largely unavoidable when assessing physical performance from one age group in any given professional soccer club academy, over time. We aimed to overcome such issues by providing individual data analysis, which is recommended in order to help inform decision-making on an individual basis. Secondly, despite the usefulness of monitoring changes in physical capacities throughout a competitive soccer season, it remains unclear whether such enhancements translate to actual improvements in on-field soccer performance. Such research is scarce, although Wisloff et al. (38) have previously reported that improved lower body strength and jump height are associated with superior results when compared between two professional Norwegian teams. Thus, it is our recommendation that future research aims to further bridge the gap between physical fitness and on-field performance, which would provide a more cohesive understanding of how strength and conditioning can support athletes in a sport like soccer.

Practical Applications

The data from the present study highlights that the physical tests most sensitive to change were the SLCMJ and linear speed tests. When considering the SLCMJ specifically, jump height (i.e., the outcome measure) showed the largest improvements out of all metrics. Although the present utilized a force platform to gather more in-depth data on jump strategy, it appears the outcome measure was the most sensitive to change. Thus, for practitioners who do not have extensive budgets, they can still utilize cheaper testing options (e.g., My Jump 2) and still accurately gather the same outcome measures based data. Additionally, given the common use of linear speed testing in soccer players, implementing such tests is likely to be viable for most practitioners as well. Therefore, the results of the present study can help to inform monitoring practice for coaches, regardless of whether they have access to more expensive equipment.

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Table 1. Overview of weekly structure for conditioning and weight room training during both pre and in-season periods.

Pre-Season Schedule							
Time of Day	*Monday*	*Tuesday*	*Wednesday*	*Thursday*	*Friday*	*Saturday*	*Sunday*
Morning	Weight Room	Technical	Recovery	Technical	Small Sided Games	Rest	Rest
Afternoon	Technical	Weight Room	Rest	Rest			
In-Season Schedule							
Morning	Weight Room	Unit Training	Recovery	Technical	Match Preparation	Game	Rest
Afternoon	Individual	Weight Room	Rest	Rest		Rest	

Note: Technical training took place with the manager / head coach on the pitch. Recovery sessions included foam rolling and static and dynamic stretching. Examples of small sided games were 3 vs. 3 (15-min duration) or 7 vs. 7 (4 x 8-min duration separated by 2-min recovery). Individual and unit training relates to position-specific training or drills on the pitch.

Table 2. Example training programme with a primary focus on strength in pre-season and power / maintenance of strength during in-season.

		Pre-Season Program		
Exercise	*Sets*	*Repetitions*	*Load*	*Rest*
Trap Bar Deadlift	3	4	87.5% 1RM	4-mins
Romanian Deadlift	3	5	85% 1RM	4-mins
DB Split Squat	3	6 each leg	1-2 RIR	3-mins
DB Lateral Lunge	3	6 each leg	1-2 RIR	3-mins
		In-Season Program		
Prowler Push	3	10-m*	50% BM	4-mins
Hang Clean/High Pull	3	3	85% 1RM	4-mins
Trap Bar Deadlift	3	4	87.5% 1RM	4-mins
Nordics	3	4	N/A	4-mins

** represents distance travelled rather than repetitions performed.*

DB = dumbbells; RIR = repetitions in reserve; RM = repetition maximum; m = meters; BM = body mass; N/A = not applicable.

Table 3. Reliability data using the coefficient of variation (CV) and intraclass correlation coefficient (ICC) with 95% confidence intervals (CI) for all fitness tests at pre, mid and end of season time points.

	Pre-Season		**Mid-Season**		**End-Season**	
Fitness Test	*CV (%)*	*ICC (95% CI)*	*CV (%)*	*ICC (95% CI)*	*CV (%)*	*ICC (95% CI)*
CMJ:						
Jump height	2.91	0.86 (0.74, 0.93)	3.12	0.89 (0.79, 0.94)	3.17	0.92 (0.84, 0.96)
RSI-Mod	6.95	0.93 (0.86, 0.97)	4.95	0.94 (0.89, 0.97)	5.10	0.95 (0.90, 0.97)
TTTO	4.50	0.93 (0.87, 0.97)	3.53	0.96 (0.92, 0.98)	3.88	0.96 (0.92, 0.98)
CM Depth	5.58	0.90 (0.82, 0.95)	5.38	0.91 (0.84, 0.96)	8.64	0.81 (0.66, 0.90)
SLCMJ-L:						
Jump height	5.81	0.56 (0.31, 0.76)	3.84	0.83 (0.70, 0.92)	4.26	0.76 (0.58, 0.88)
RSI-Mod	8.11	0.89 (0.79, 0.94)	7.05	0.93 (0.87, 0.97)	7.70	0.93 (0.87, 0.97)
TTTO	6.52	0.81 (0.66, 0.90)	3.49	0.96 (0.92, 0.98)	3.55	0.96 (0.92, 0.98)
CM Depth	7.62	0.76 (0.59, 0.88)	7.31	0.72 (0.52, 0.85)	8.64	0.67 (0.46, 0.83)
SLCMJ-R:						
Jump height	6.93	0.59 (0.34, 0.78)	4.03	0.78 (0.61, 0.89)	4.61	0.74 (0.56, 0.87)
RSI-Mod	9.51	0.84 (0.72, 0.92)	7.42	0.91 (0.83, 0.96)	7.93	0.90 (0.82, 0.95)
TTTO	5.64	0.87 (0.76, 0.94)	3.09	0.97 (0.94, 0.99)	3.75	0.96 (0.91, 0.98)
CM Depth	7.04	0.91 (0.82, 0.95)	8.10	0.85 (0.73, 0.93)	8.66	0.70 (0.49, 0.84)
Linear Speed:						
5-m	1.48	0.62 (0.38, 0.79)	1.69	0.57 (0.33, 0.77)	1.88	0.69 (0.48, 0.84)
10-m	1.54	0.60 (0.43, 0.79)	1.46	0.65 (0.43, 0.81)	2.00	0.61 (0.44, 0.78)
20-m	1.24	0.69 (0.49, 0.84)	1.03	0.84 (0.71, 0.92)	1.35	0.82 (0.68, 0.91)
30-m	1.05	0.80 (0.65, 0.90)	1.60	0.64 (0.41, 0.80)	1.16	0.86 (0.74, 0.93)
COD Speed:						
505-L	0.89	0.91 (0.83, 0.96)	0.83	0.93 (0.87, 0.97)	2.00	0.71 (0.48, 0.86)
505-R	0.88	0.91 (0.83, 0.96)	0.94	0.89 (0.80, 0.95)	0.96	0.86 (0.74, 0.93)

CMJ = countermovement jump; RSI-Mod = reactive strength index modified; TTTO = time to take-off; CM = countermovement; SLCMJ = single leg countermovement jump; L = left; R = right.

Table 4. Mean ± standard deviation (SD) fitness testing data for pre, mid and end of season, and Hedges *g* effect size data with 95% confidence intervals (CI) showing the magnitude of difference between time points.

	Mean ± SD			**Hedges *g* (95% CI)**		
Fitness Test	*Pre-Season*	*Mid-Season*	*End-Season*	*Pre to Mid*	*Pre to End*	*Mid to End*
CMJ:						
Jump height (cm)	36.77 ± 2.88	38.72 ± 3.34	40.11 ± 3.46	**0.61 (0.07, 1.16)**	**1.03 (0.46, 1.59)**	0.40 (-0.14, 0.94)
RSI-Mod	0.48 ± 0.12	0.51 ± 0.10	0.51 ± 0.09	0.27 (-0.27, 0.80)	0.28 (-0.26, 0.81)	0.00 (-0.53, 0.53)
TTTO (ms)	826.32 ± 157.50	769.68 ± 132.77	766.84 ± 134.84	-0.38 (-0.92, 0.16)	-0.40 (-0.94, 0.14)	-0.02 (-0.55, 0.51)
CM Depth (cm)	30.61 ± 5.77	31.65 ± 5.58	32.30 ± 5.90	0.18 (-0.36, 0.71)	0.28 (-0.25, 0.82)	0.11 (-0.42, 0.64)
SLCMJ-L:						
Jump height (cm)	20.62 ± 2.28	23.59 ± 2.03	25.21 ± 1.68	**1.35 (0.76, 1.94)**	**2.24 (1.56, 2.93)**	**0.73 (0.18, 1.29)**
RSI-Mod	0.26 ± 0.06	0.30 ± 0.07	0.32 ± 0.07	**0.60 (0.06, 1.15)**	**0.90 (0.34, 1.46)**	0.28 (-0.26, 0.82)
TTTO (ms)	873.18 ± 208.76	827.77 ± 150.75	812.35 ± 140.77	-0.24 (-0.78, 0.29)	-0.33 (-0.87, 0.20)	-0.10 (-0.64, 0.43)
CM Depth (cm)	20.44 ± 3.51	21.90 ± 2.87	23.86 ± 2.97	0.45 (-0.09, 0.99)	**1.03 (0.46, 1.60)**	**0.66 (0.11, 1.20)**
SLCMJ-R:						
Jump height (cm)	20.37 ± 2.24	23.41 ± 1.79	25.11 ± 1.87	**1.47 (0.87, 2.07)**	**2.25 (1.57, 2.93)**	**0.91 (0.35, 1.47)**
RSI-Mod	0.26 ± 0.06	0.30 ± 0.06	0.31 ± 0.06	**0.65 (0.10, 1.20)**	**0.82 (0.26, 1.37)**	0.16 (-0.37, 0.70)
TTTO (ms)	859.60 ± 151.10	827.21 ± 152.82	809.35 ± 138.63	-0.21 (-0.74, 0.33)	-0.33 (-0.88, 0.20)	-0.12 (-0.65, 0.41)
CM Depth (cm)	21.49 ± 5.01	22.68 ± 3.47	24.05 ± 2.83	0.27 (-0.27, 0.81)	**0.62 (0.07, 1.16)**	0.42 (-0.12, 0.96)
Linear Speed:						
5-m (s)	0.99 ± 0.02	0.97 ± 0.02	0.95 ± 0.02	**-0.98 (-1.54, -0.41)**	**-1.96 (-2.61, -1.31)**	**-0.98 (-1.54, -0.41)**
10-m (s)	1.69 ± 0.03	1.67 ± 0.03	1.63 ± 0.03	**-0.65 (-1.20, -0.10)**	**-1.96 (-2.61, -1.31)**	**-1.31 (-1.89, -0.72)**
20-m (s)	2.91 ± 0.05	2.87 ± 0.06	2.84 ± 0.06	**-0.71 (-1.26, -0.16)**	**-1.24 (-1.82, -0.66)**	-0.49 (-1.03, 0.05)
30-m (s)	4.04 ± 0.08	3.98 ± 0.13	3.94 ± 0.09	**-0.54 (-1.09, -0.01)**	**-1.15 (-1.73, -0.57)**	-0.35 (-0.89, 0.19)
COD Speed:						
505-L (s)	2.46 ± 0.07	2.43 ± 0.07	2.40 ± 0.10	-0.42 (-0.96, 0.12)	**-0.68 (-1.23, -0.13)**	-0.34 (-0.88, 0.20)
505-R (s)	2.45 ± 0.06	2.43 ± 0.06	2.38 ± 0.06	-0.33 (-0.86, 0.21)	**-1.14 (-1.72, -0.57)**	**-0.82 (-1.37, -0.26)**

N.B: effect sizes in ***bold*** *signify statistically significant change ($p < 0.05$).*

CMJ = countermovement jump; RSI-Mod = reactive strength index modified; TTTO = time to take-off; CM = countermovement; SLCMJ = single leg countermovement jump; L = left; R = right; cm = centimetres; ms = milliseconds; s = seconds.

Table 5. Mean ± standard deviation (SD) inter-limb asymmetry and bilateral deficit data for pre, mid and end of season, and Hedges *g* effect size data with 95% confidence intervals (CI) showing the magnitude of difference between time points.

	Mean ± SD			**Hedges *g* (95% CI)**		
Jump Metrics	*Pre-Season*	*Mid-Season*	*End-Season*	*Pre to Mid*	*Pre to End*	*Mid to End*
Asymmetry (%)						
Jump height	5.24 ± 4.11	4.31 ± 2.87	1.83 ± 1.55	-0.26 (-0.79, 0.28)	**-1.07 (-1.65, -0.50)**	**-1.05 (-1.62, -0.48)**
RSI-Mod	6.15 ± 5.42	6.66 ± 5.14	5.98 ± 4.50	0.09 (-0.44, 0.63)	-0.03 (-0.57, 0.50)	-0.14 (-0.67, 0.40)
TTTO	7.06 ± 6.74	1.86 ± 2.21	2.36 ± 1.74	**-1.02 (-1.58, -0.45)**	**-0.93 (-1.50, -0.37)**	0.25 (-0.29, 0.78)
CM Depth	9.83 ± 7.18	5.57 ± 4.93	4.28 ± 3.23	**-0.68 (-1.23, -0.13)**	**-0.98 (-1.54, -0.41)**	-0.30 (-0.84, 0.23)
Bilateral Deficit (%)						
Jump height	9.79 ± 7.46	17.51 ± 5.60	20.22 ± 5.40	**1.15 (0.57, 1.72)**	**1.57 (0.96, 2.18)**	0.48 (-0.06, 1.02)
RSI-Mod	7.05 ± 20.43	13.27 ± 17.08	16.55 ± 15.28	0.32 (-0.21, 0.86)	0.52 (-0.03, 1.06)	0.20 (-0.34, 0.73)
TTTO	51.86 ± 6.46	53.19 ± 5.43	52.52 ± 5.56	0.22 (-0.32, 0.75)	0.11 (-0.43, 0.64)	-0.12 (-0.65, 0.41)
CM Depth	25.78 ± 13.91	28.57 ± 11.20	32.35 ± 10.23	0.22 (-0.32, 0.75)	0.53 (-0.02, 1.07)	0.35 (-0.19, 0.88)

N.B: effect sizes in ***bold*** *signify statistically significant change ($p < 0.05$).*

CMJ = countermovement jump; RSI-Mod = reactive strength index modified; TTTO = time to take-off; CM = countermovement; SLCMJ = single leg countermovement jump; L = left; R = right; cm = centimetres; ms = milliseconds; s = seconds.

Table 6. Kappa coefficients showing levels of agreement (with descriptor) for the direction of asymmetry between time points.

Asymmetry Metric	Pre to Mid	Pre to End	Mid to End
Jump height	0.27 (Fair)	0.37 (Fair)	0.15 (Slight)
RSI-Mod	0.14 (Slight)	0.36 (Fair)	0.37 (Fair)
TTTO	-0.17 (Poor)	0.06 (Slight)	0.37 (Fair)
CM Depth	-0.05 (Poor)	0.19 (Slight)	-0.13 (Poor)

RSI-Mod = reactive strength index modified; TTTO = time to take-off; CM = countermovement.

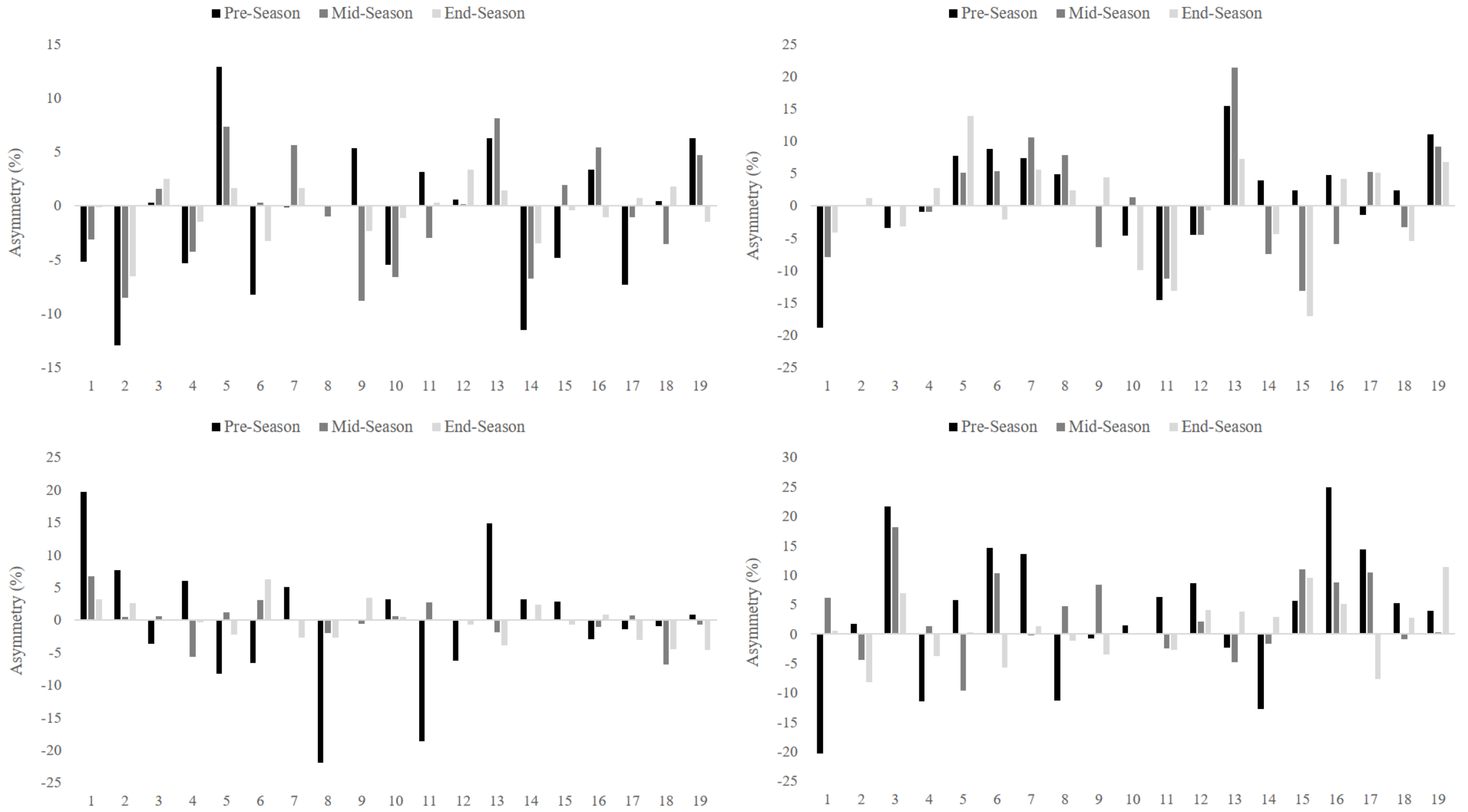

Figure 1. Individual asymmetry data for jump height (top left), reactive strength index modified (top right), time to take-off (bottom left) and countermovement depth (bottom right). *Note:* bars above 0 indicate right limb dominance and below 0 indicates left limb dominance.

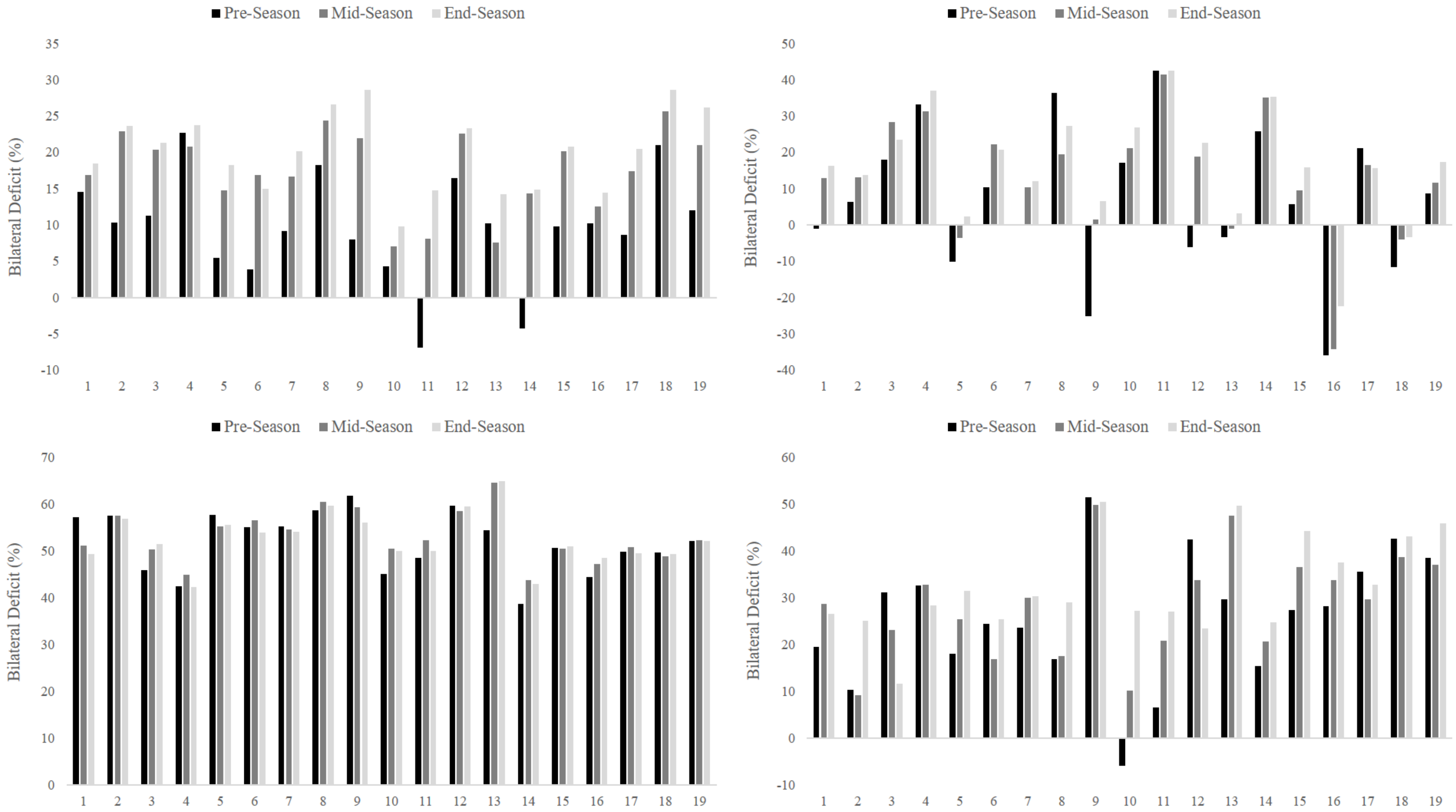

Figure 2. Individual bilateral deficit data for jump height (top left), reactive strength index modified (top right), time to take-off (bottom left) and countermovement depth (bottom right). *Note:* bars below 0 indicates bilateral facilitation.