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Chris Bishop
London Sport Institute, Middlesex University

Anthony Weldon
Faculty of Management and Hospitality, Technological and Higher Education Institute of Hong Kong, Vocational Training Council, anthony-weldon@thei.edu.hk

Jon Hughes
Department of Sport and Exercise Sciences, University of Gloucestershire

Irineu Loturco
Department of Sport Science and Research, Nucleus of High Performance Sport, Sao Paulo, Brazil

Anthony Turner
London Sport Institute, Middlesex University

See next page for additional authors

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Authors

Chris Bishop, Anthony Weldon, Jon Hughes, Irineu Loturco, Anthony Turner, and Paul Read

Seasonal Variation of Physical Performance and Inter-limb Asymmetry in Professional Cricket Athletes

Chris Bishop,[1] Anthony Weldon,[2] Jon Hughes,[3] Jon Brazier,[4] Irineu Loturco,[5] Anthony Turner,[1] and Paul Read[6]

[1]London Sport Institute, Middlesex University, Greenlands Lane, London, United Kingdom; [2]Hong Kong Cricket Association, Hong Kong, China; [3]Department of Sport and Exercise Sciences, University of Gloucestershire, United Kingdom; [4]Department of Sports Therapy, University of Hertfordshire, United Kingdom; [5]Department of Sport Science and Research, Nucleus of High Performance Sport, Sao Paulo, Brazil; and [6]Athlete Health and Performance Research Center, Aspetar Orthopaedic and Sports Medicine Hospital, Doha, Qatar

Abstract

Bishop, C, Weldon, A, Hughes, J, Brazier, J, Loturco, I, Turner, A, and Read, P. Seasonal variation of physical performance and interlimb asymmetry in professional cricket athletes. *J Strength Cond Res* 35(4): 941–948, 2021—The aims of this study were to: (a) determine the seasonal variation of physical performance in professional cricket players and (b) determine the seasonal variation of interlimb asymmetries in the same cohort of professional players. Fifteen male professional cricket players (age: 20.60 ± 1.59 years; height: 1.82 ± 0.08 m; and body mass: 78.70 ± 11.23 kg) performed unilateral countermovement jumps (CMJs), unilateral drop jumps, 10 m sprints and 505 change of direction (COD) speed tests at pre (March), mid (June), and end (September) of the 2018 season. Interlimb asymmetry was quantified in the unilateral CMJ (jump height and concentric impulse), unilateral drop jump (jump height and reactive strength index [RSI]), and 505 (total time and COD deficit). Significant changes ($p < 0.05$) were evident for the following tests: unilateral CMJ (effect size [ES] range = 0.67–1.00), 505 on the right leg (ES = 0.70), 10 m (ES range = −1.39 to 0.70), and COD deficit (ES range = 0.70–0.80), with the largest changes evident for 10-m sprint. No significant differences were evident in drop jump performance throughout the season. For the magnitude of asymmetry, significant changes in jump height asymmetry from the unilateral CMJ were evident from mid to end of season (ES = 0.72). For the direction of asymmetry, levels of agreement ranged from poor to substantial in the unilateral CMJ (kappa = −0.21 to 0.72), fair to substantial in the unilateral drop jump (kappa range = 0.33 to 0.74), and slight to moderate during the 505 test (kappa range = 0.06 to 0.44), with RSI showing noticeably better results than other tests or metrics. These data show that the largest changes in performance scores throughout the season came from the 10-m test, which practitioners may wish to consider implementing if not doing so already. Furthermore, both unilateral jump tests showed their use for asymmetry interpretation, which practitioners may wish to consider implementing in to their test batteries. Specifically, jump height asymmetry during the unilateral CMJ was the only metric to exhibit meaningful changes between time points, whereas RSI was the metric that exhibited more consistent limb dominance characteristics for the direction of asymmetry.

Key Words: between-limb differences, change of direction, jumping, speed

Introduction

Cricket is a team sport which takes many formats during competition. Historically, at the international level, test cricket involves countries competing against each other over a maximum of 5 days, with players often required to perform for multiple hours at a time. In the last 20 years, 50-over and Twenty-Twenty (T20) cricket has been developed, offering a faster pace to the sport in these formats. Bowlers are required to deliver 6 balls per over and are often required to perform multiple overs during competition. Typically, fast bowlers can release the ball in excess of 145 $km \cdot h^{-1}$ (32), often reaching speeds up to 6.1 $m \cdot s^{-1}$ during the run-up before releasing the ball (1); thus, appropriate physical preparation for such positions seems key (13,14). For batters, an innings can last several hours with repeated sprints, and 180° changes of direction (COD) often required between the wickets when attempting to score runs (30), highlighting that physical preparation for batters is also critical. From a fielding perspective, involvement can be sporadic over many hours; however, players are required to perform at any given moment; thus, resistance to fatigue is paramount. Furthermore, the introduction of the faster-paced 50-over and T20 formats have meant that enhanced physical capacity is even more important, in an attempt to gain a competitive advantage over opponents (24). Thus, the inclusion of fitness testing in cricket has become increasingly common and important, enabling practitioners to prepare their players for the different demands faced by each format of the sport.

When critiquing the available body of evidence in cricket, studies have often investigated physical-specific and cricket-specific performance (12,15,21,29). However, data are predominantly conducted at single time points with little literature available relating to the seasonal variation of these physical qualities. Carr et al. (8) reported changes in power and speed in 12 English county cricket players, using the

Address correspondence to Chris Bishop, C.Bishop@mdx.ac.uk.

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bilateral countermovement jump (CMJ) and 20-m sprint performed at the start and end of preseason, mid, and end-season time points. Results showed a progressive decrease in the performance of both tests at both mid and end-season time points, compared with the end of preseason (CMJ: pre = 44.5 cm, mid = 43.5 cm, and end = 42.6 cm; 20 m: pre = 3.00 seconds, mid = 3.07 seconds, and end = 3.12 seconds). Herridge et al. (19) monitored changes in speed, power, agility, and endurance during a 20-week off-season period in elite cricket players. A concurrent approach to physical development was used with a combination of strength endurance, strength, and power training conducted, in conjunction with aerobic endurance and speed sessions. Significant improvements were evident in CMJ (effect size [ES] = 0.75), single leg CMJ (ES = 0.50–0.67), broad jump (ES = 2.33), reactive strength index (RSI, ES = 0.83), linear speed (5 m, ES = 2.80; 10 m, ES = 2.50; 20 m, ES = 1.68), but not agility (ES = 0.26) performance (19). Despite these data, further information relating to seasonal variation of physical qualities in cricket is scarce and requires further research to better understand the changing nature of these capacities during a competitive season.

An additional consideration under-researched in the sport of cricket relates to interlimb asymmetry. Bowlers and batters are likely to favor using one particular side to perform their respective actions; thus, the development of interlimb asymmetries seems likely in this sport. For example, Kountouris et al. (23) investigated the level of asymmetry in a cross-sectional area (CSA) of the quadratus lumborum muscle in 23 elite fast bowlers. Sixty-five percent of the sample showed larger CSA on the dominant (bowling arm) side, with mean asymmetry of 11.5% (range = 0.3–30.7%), highlighting the vast difference in magnitude of CSA asymmetry of the quadratus lumborum muscle. A similar investigation was conducted by Gray et al. (18) who investigated the association between abdominal muscle symmetry and incidence of low back pain in fast bowlers. Interestingly, combined thickness of the internal and external obliques and transverse abdominus muscles was significantly greater (p = 0.02) on the nondominant side, for bowlers with no low back pain. Further to this, those bowlers who reported pain actually exhibited symmetry in combined abdominal muscle thickness; thus, highlighting that asymmetry is likely to be a functional adaptation of the sport, especially for fast bowlers. Despite the usefulness of this information, asymmetry literature relating to the lower body in cricket is scarce, especially when tracked over time. In addition, recent investigations relating to asymmetry have highlighted the importance of monitoring the "direction of imbalance" (i.e., which limb scores better out of the 2) (2,4). This provides practitioners with an understanding of limb dominance for a given task and helps to contextualize whether such data are consistent when monitored over repeated time points (4,5). However, such data for the sport of cricket does not seem to be evident.

Therefore, the aims of this exploratory study were to: (a) determine the seasonal variation of physical performance in professional cricket players and (b) determine the seasonal variation of the magnitude and direction of interlimb asymmetries in the same cohort of professional players. It was hypothesized that the demands of a long in-season period would invoke significant changes in physical performance. However, meaningful changes in the magnitude of asymmetry have recently been shown not to occur, whereas substantial variation existed in the direction of asymmetry when tracked over time (5). Thus, it was hypothesized that the magnitude of asymmetry would remain consistent, but levels of agreement for the direction of asymmetry would vary.

Methods

Experimental Approach to the Problem

This study used a repeated measures design in a convenience sample of professional cricket players from March to September, during the 2018 cricket season. Unilateral jump tests, linear speed, and COD tests were all performed during the end of preseason (March), midseason (June), and end of season (September), to monitor both physical performance and jumping asymmetries. When considering the players' weekly schedule, on average, each player undertook: 2–3 competitive matches (1–2 for T20 and 1–2 for county fixtures), 2–3 on-field training sessions (consisting of technical-based and conditioning-based activities such as sprinting and COD drills), 1–2 resistance training sessions (focusing on the maintenance of lower-body strength and power). For all 3 time points, all testing was conducted in a randomized order, on a single day to ensure accuracy in testing, with no training or competition the day before. All athletes were previously familiarized with testing protocols as these formed a part of their regular testing battery.

Subjects

Fifteen male professional cricket players (age: 20.60 ± 1.59 years; height: 1.82 ± 0.08 m; and body mass: 78.70 ± 11.23 kg; *SD*) from a Division 1 county club first team squad volunteered to participate in this study. All players were contracted to the same club during the 2018 cricket season and had a minimum of 5 years' competitive cricket experience and a minimum of 2 years' structured strength and conditioning training experience. Players were required to be free from injury for at least 4 weeks before each testing session and deemed fit to participate fully in training and competition by the respective clubs' medical departments. This resulted in the removal of 4 players from the total data set. This 4-week time frame was chosen to limit the impact of any compensatory movement patterns because of previous minor muscle injuries. Further to this, no major injuries (classified as >28 days) (16) were reported for all players throughout the duration of this study, with the longest period with no training being 7 days for one player. Written informed consent was provided by all subjects, and this study was approved by the London Sport Institute Research and Ethics Committee at Middlesex University.

Procedures

All testing was conducted at the same time of the day (08:00–10:00) to limit the impact of circadian rhythms (25). A standardized dynamic warm up was performed each time and consisted of a single set of 10 repetitions of multiplanar lunges, inchworms, Spiderman's, and bodyweight squats, followed by 3 practice trials of each respective test, on each limb where applicable. Athletes were asked to perform practice trials at 60, 80 and 100% of their perceived maximal effort, with jump and COD tests practiced on both limbs. Three minutes of rest was provided between the last practice trial and the start of the first test, and 60 seconds of rest was provided between trials during jump tests and 3 minutes between trials for the speed and COD tests. For jump tests, athletes performed 3 trials on each leg at each time point with the mean value taken from all trials on each side and asymmetry subsequently computed thereafter. Given asymmetry has been shown to be a variable concept (2,4,5), averaging data were deemed appropriate to capture some of the variability that may have existed between trials.

Unilateral Countermovement Jump. Subjects were instructed to step onto the center of a single uniaxial force platform (size: 0.42 × 0.42 m; PASPORT force plate, PASCO Scientific, CA) sampling at 1,000 Hz, with their designated test leg. Hands were placed on hips and were required to remain in the same position throughout the duration of the test. Test instructions were the same at each time point with athletes asked to "jump as high as you can." The jump was initiated by performing a countermovement to a self-selected depth (which was reinforced verbally to the players during practice trials) before accelerating vertically as fast as possible into the air. The test leg was required to remain fully extended throughout the flight phase of the jump before landing back onto the force plate as per the set up. The nonjumping leg was slightly flexed with the foot hovering at the midshin level, and no additional swinging of this leg was allowed during trials. Recorded metrics included jump height and concentric impulse, with definitions for their quantification conducted in line with suggestions by Gathercole et al. (17) and Chavda et al. (9). 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). Concentric impulse was defined as the net force (where net force was calculated by subtracting body weight from vertical force) multiplied by the time taken to produce it; i.e., the area under the net force-time curve. The first meaningful change in force was established when values surpassed ± 5 *SD*) of each subject's body weight, minus 30 milliseconds to ensure velocity was at zero (27). The force plate was calibrated before each data collection, and all force traces were extracted unfiltered and subsequently copied into a custom-made spreadsheet previously suggested (9). These 2 metrics were chosen for different reasons. First, jump height is typically the metric that all athletes and technical coaches are interested in and provides a clear understanding of the outcome measure for unilateral vertical jumping. By contrast, this provides no clear understanding of jump strategy, a concept which previous research has shown may be more sensitive at detecting a true change between test sessions (17). Consequently, concentric impulse was selected as an additional metric of interest, which has been reported in recent unilateral jump investigations (2,5).

Unilateral Drop Jump. The unilateral DJ was performed using the OptoJump measurement system (Microgate, Bolzano, Italy), with all athletes required to step off an 18-cm box. This height was chosen in line with previous research using this test (4,5,25). With hands fixed on hips, subjects were required to step off the box with their designated test leg which subsequently landed on the hard rubber flooring between the optimal measurement system below. On landing, subjects were instructed to "minimize ground contact time and jump as high as possible" thereafter in line with previous suggestions (4,5,25). Recorded metrics included jump height (calculated from the flight time method) and RSI, quantified using the equation flight time/ground contact time (4,5,25). Similar to the unilateral CMJ, jump height was selected for ease of understanding and interpretation for technical coaches and athletes. In addition, numerous studies have used drop jumps to measure and report RSI (3–5,19,25), which provides an understanding of how high an athlete can jump in as short a time as possible. Thus, RSI also provides more information about an athlete's jump strategy during this task.

10-m Sprint Test. Dual beam electronic timing gates (Brower Timing Systems, Draper, UT) were positioned at 0 and 10 m, at a height of 1 m, enabling athlete's acceleration to be measured. Athletes started the test in a staggered 2-point stance with toes positioned 0.3 m 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 allow time to be recorded to the nearest 100th of a second. Three trials were performed on an outdoor grass cricket pitch with a mean of 3 trials used at each time point for further analysis. All players performed sprints and 505 tests in the same footwear used during competitive matches.

505 Change of Direction Speed Test. 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. Each player completed 6 trials (3 turning off the right leg and 3 turning off the left leg) with a consistent turning direction being maintained for 3 trials in a row but with the initial direction being randomly allocated at each test session. 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. The mean of 3 trials were used on each limb at each time point for subsequent data analysis. The COD deficit was also calculated for left and right sides, by subtracting the 10-m linear sprint time from the 505 times. In line with previous suggestions, this provided a better indication of each player's COD ability (26).

Statistical Analyses

All data were initially recorded as means and *SD* in Microsoft Excel and later transferred to SPSS (version 25.0; SPSS, Inc., Armonk, NY). Normality was assessed using the Shapiro-Wilk test and showed asymmetry data to be non-normally distributed ($p < 0.05$), whereas test scores were normally distributed. Within-session reliability data were computed at each time point using an average measures 2-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 (22) where values >0.9 = excellent, 0.75–0.9 = good, 0.5–0.75 = moderate, and <0.5 = poor. The CV was calculated by the formula: (*SD* [trials 1–3]/average [trials 1–3] × 100) with values ≤10% suggested to be considered acceptable (11).

A repeated measures analysis of variance (ANOVA) was conducted to determine differences in test scores and a Friedman's ANOVA to determine differences in asymmetry scores between time points for all metrics, with statistical significance set at $p < 0.05$. The magnitude of change was calculated between time points using Cohen's *d* ESs with 95% confidence intervals using the formula: $(\text{Mean}_{T1} - \text{Mean}_{T2})/SD_{\text{pooled}}$, where T1 and T2 represent the respective time points in question (e.g., pre, mid, or end-season). These were interpreted in line with Hopkins et al. (20) where <0.2 = trivial, 0.2–0.6 = small, 0.6–1.2 = moderate, 1.2–2.0 = large, 2.0–4.0 = very large, and >4.0 = near perfect.

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 (2,6). 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) (2,4,5). Kappa coefficients were calculated to determine the levels of agreement for how consistently an asymmetry favored

Table 1

Within-session reliability data (i.e., calculated between 3 repetitions) using the coefficient of variation (CV) and intraclass correlation coefficients (ICC) with 95% confidence intervals (CI) for all test measures at pre, mid, and end of season.*

Fitness Test	Preseason CV (%)	Preseason ICC (95% CI)	Midseason CV (%)	Midseason ICC (95% CI)	End-season CV (%)	End-season ICC (95% CI)
UCMJ:						
Jump height-L	8.0	0.87 (0.74–0.94)	7.8	0.81 (0.63–0.91)	8.4	0.79 (0.60–0.91)
Jump height-R	7.8	0.83 (0.66–0.92)	8.7	0.83 (0.67–0.92)	8.1	0.86 (0.71–0.94)
CON Impulse-L	4.7	0.96 (0.92–0.98)	7.7	0.78 (0.59–0.90)	9.0	0.74 (0.53–0.88)
CON Impulse-R	6.0	0.90 (0.80–0.96)	8.1	0.89 (0.77–0.95)	9.6	0.76 (0.55–0.89)
UDJ:						
Jump height-L	8.6	0.89 (0.77–0.95)	8.8	0.84 (0.68–0.93)	7.3	0.89 (0.78–0.95)
Jump height-R	9.7	0.81 (0.64–0.92)	8.5	0.89 (0.78–0.95)	6.4	0.93 (0.86–0.97)
RSI-L	5.2	0.88 (0.76–0.95)	4.6	0.85 (0.70–0.93)	4.7	0.85 (0.71–0.93)
RSI-R	5.5	0.75 (0.53–0.88)	6.8	0.80 (0.61–0.91)	4.4	0.89 (0.78–0.95)
COD and Linear Speed:						
505-L	2.4	0.74 (0.53–0.88)	1.9	0.77 (0.56–0.89)	1.9	0.82 (0.66–0.92)
505-R	1.9	0.88 (0.75–0.95)	2.6	0.81 (0.60–0.90)	1.6	0.76 (0.55–0.89)
10 m	2.3	0.72 (0.49–0.87)	2.6	0.72 (0.49–0.87)	2.3	0.71 (0.48–0.95)

*UCMJ = unilateral countermovement jump; L = left; R = right; CON = concentric; UDJ = unilateral drop jump; RSI = reactive strength index; COD = change of direction; m = meters.

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 2 methods after any agreement by chance has been removed (10). Kappa values were interpreted in line with suggestions from Viera and Garrett (31), 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. Given that asymmetry is a ratio number (i.e., calculated as a percentage from left and right scores), use of the kappa coefficient serves as an alternative statistical method to more traditional methods of reliability (e.g., CV and ICC) because it is able to account for consistency in the direction of asymmetry, something which traditional measures cannot accomplish when using the absolute percentage value.

Results

Table 1 shows absolute (CV) and relative (ICC) reliability data for all tests at each individual time point. All CV values were acceptable at each time point (<10%), and ICC's ranged from moderate to excellent in preseason (0.72–0.96), moderate to good at midseason (0.72–0.89), and moderate to excellent at the end of season (0.71–0.93).

Table 2 shows mean and *SD* for all tests at each time point. For the unilateral CMJ, significant reductions were evident in jump height on the left leg between pre and midseason (ES = 1.00) and pre and end-season (ES = 0.67) time points. Concentric impulse showed a significant reduction from pre to midseason (ES = 0.69), for the left leg. For linear speed, the 10-m sprint time

Table 2

Mean and *SD* data, and Cohen's *d* effect sizes with 95% confidence intervals (CI) between time points.*†

Fitness Test	Mean ± *SD* Preseason (March)	Mean ± *SD* Midseason (June)	Mean ± *SD* End-season (September)	Cohen's *d* (95% CI) Pre-Mid	Cohen's *d* (95% CI) Pre-End	Cohen's *d* (95% CI) Mid-End
UCMJ:						
Jump height-L (m)	0.19 ± 0.03	0.16 ± 0.03	0.17 ± 0.03	**−1.00 (−1.61 to −0.34)**	**−0.67 (−1.26 to −0.03)**	0.33 (−0.28 to 0.93)
Jump height-R (m)	0.18 ± 0.03	0.17 ± 0.03	0.17 ± 0.04	−0.33 (−0.93 to 0.28)	−0.28 (−0.88 to 0.33)	0.00 (−0.60 to 0.60)
CON Impulse-L (N·s)	137.8 ± 27.5	121.2 ± 19.7	125.8 ± 20.9	**−0.69 (−1.29 to −0.06)**	−0.49 (−1.09 to 0.13)	0.23 (−0.38 to 0.82)
CON Impulse-R (N·s)	137.5 ± 26.0	123.2 ± 21.1	126.2 ± 22.2	−0.60 (−1.20 to 0.03)	−0.47 (−1.06 to 0.15)	0.14 (−0.46 to 0.74)
UDJ:						
Jump height-L (m)	0.18 ± 0.04	0.18 ± 0.04	0.18 ± 0.03	0.00 (−0.60 to 0.60)	0.00 (−0.60 to 0.60)	0.00 (−0.60 to 0.60)
Jump height-R (m)	0.18 ± 0.03	0.17 ± 0.04	0.19 ± 0.04	−0.28 (−0.88 to 0.33)	0.28 (−0.33 to 0.88)	0.50 (−0.12 to 1.10)
RSI-L	1.33 ± 0.15	1.32 ± 0.18	1.36 ± 0.17	−0.06 (−0.66 to 0.54)	0.19 (−0.42 to 0.78)	0.23 (−0.38 to 0.82)
RSI-R	1.28 ± 0.15	1.27 ± 0.18	1.32 ± 0.17	−0.06 (−0.66 to 0.54)	0.25 (−0.36 to 0.85)	0.29 (−0.33 to 0.88)
COD and Linear Speed:						
505-L (s)	2.24 ± 0.10	2.29 ± 0.09	2.25 ± 0.11	−0.53 (−1.12 to 0.10)	−0.10 (−0.69 to 0.51)	0.40 (−0.22 to 0.99)
505-R (s)	2.23 ± 0.12	2.29 ± 0.10	2.23 ± 0.07	−0.54 (−1.14 to 0.08)	0.00 (−0.60 to 0.60)	**0.70 (0.06 to 1.29)**
10 m (s)	1.78 ± 0.07	1.90 ± 0.10	1.84 ± 0.07	**−1.39 (−2.02 to −0.69)**	**−0.86 (−1.46 to −0.21)**	**0.70 (0.06 to 1.29)**
CODD-L	0.45 ± 0.08	0.39 ± 0.07	0.40 ± 0.12	**0.80 (0.15 to 1.40)**	0.49 (−0.13 to 1.09)	−0.10 (−0.70 to 0.50)
CODD-R	0.45 ± 0.09	0.38 ± 0.10	0.39 ± 0.08	**0.74 (0.10 to 1.34)**	**0.70 (0.07 to 1.30)**	−0.11 (−0.71 to 0.49)

*UCMJ = unilateral countermovement jump; L = left; R = right; m = meters; N·s = Newton seconds; CON = concentric; UDJ = unilateral drop jump; RSI = reactive strength index; COD = change of direction; s = seconds; CODD = change of direction deficit.

†N.B: Effect sizes in bold indicate significant difference ($p < 0.05$).

Table 3

Mean interlimb asymmetry and *SD* data for each time point.*†

Asymmetry Metric (%)	Mean ± *SD* Preseason (March)	Midseason (June)	End-season (September)	Cohen's *d* (95% CI) Pre-Mid	Pre-End	Mid-End
UCMJ:						
Jump height	7.5 ± 4.7	8.3 ± 4.1	5.7 ± 2.9	0.19 (−0.42 to 0.78)	−0.45 (−1.04 to 0.17)	**−0.72 (−1.32** to **−0.09)**
CON Impulse	5.2 ± 3.6	5.4 ± 3.7	8.3 ± 6.5	0.05 (−0.55 to 0.65)	0.58 (−0.05 to 1.18)	0.55 (−0.08 to 1.14)
UDJ:						
Jump height	10.2 ± 5.8	7.5 ± 4.9	9.8 ± 4.8	−0.51 (−1.11 to 0.11)	−0.08 (−0.68 to 0.52)	0.48 (−0.15 to 1.07)
RSI	9.4 ± 5.7	8.2 ± 6.3	7.0 ± 5.3	−0.20 (−0.80 to 0.41)	−0.43 (−1.03 to 0.18)	−0.21 (−0.80 to 0.40)
COD Speed:						
505	2.2 ± 1.5	2.2 ± 1.1	2.8 ± 2.4	0.00 (−0.60 to 0.60)	0.34 (−0.28 to 0.93)	0.37 (−0.25 to 0.96)
CODD	10.0 ± 6.8	12.3 ± 6.3	15.1 ± 10.8	0.36 (−0.25 to 0.96)	0.57 (−0.06 to 1.17)	0.32 (−0.30 to 0.91)

*UCMJ = unilateral countermovement jump; CON = concentric; UDJ = unilateral drop jump; RSI = reactive strength index; COD = change of direction; CODD = change of direction deficit.

†N.B: Effect sizes in bold indicate significant difference ($p < 0.05$).

showed meaningful changes between each time point, getting significantly slower from pre to midseason (ES = −1.39) and from pre to end-season (ES = −0.86), but significantly faster from mid to end-season (ES = 0.70). For COD speed, significant differences were evident for the total time on the right leg between mid and end-season (ES = 0.70). For the COD deficit, the right leg also showed significant differences between pre and mid-season (ES = 0.74) and pre and end-season (ES = 0.70), and between pre and mid-season (ES = 0.80) on the left leg. No other significant differences were evident throughout the season.

Table 3 shows mean interlimb asymmetry data for jump and COD tests throughout the season. The only significant difference was for jump height during the unilateral CMJ between mid and end-season, corresponding to a moderate ES (0.72). All other changes were nonsignificant. Table 4 shows the kappa coefficients for the direction of asymmetry. Levels of agreement ranged from poor to substantial for the unilateral CMJ (kappa = −0.21 to 0.72), fair to substantial for the unilateral drop jump (kappa = 0.33 to 0.74), and slight to moderate for COD speed metrics (kappa = 0.06 to 0.44). Given the inherent variability evident in the direction of asymmetry across all tests, individual asymmetry data have been presented in Figures 1–3.

Discussion

The main aims of this study were to: (a) determine the seasonal variation of physical performance in professional cricket players and (b) determine the seasonal variation of interlimb asymmetries in the same cohort of professional players. Significant differences were evident throughout the season in unilateral CMJ, linear, and COD speed metrics, with the largest variation seen for 10-m sprint time. The magnitude of asymmetry was largely consistent throughout the season; however, the direction of asymmetry was highly variable, regardless of test or metric reported. This study highlights that jump, linear, and COD speed tests were able to detect changes in performance throughout a competitive cricket season and how the direction of asymmetry may be a more appropriate line of investigation for understanding the associated variation in existing side-to-side differences, compared with the magnitude alone.

When considering the first aim in this study, 10-m sprint times demonstrated the largest seasonal variation of all tests and are in part agreement with previous research (8). Carr et al. (8) showed consistent reductions in sprint times throughout a competitive season, whereas the present sample showed a reduction from pre to midseason (ES = −1.39) but were able to improve 10-m sprint performance from mid to end of season (ES = 0.70). Providing a true reasoning for the reduction in performance during midseason is somewhat challenging; however, fixture density was slightly higher in the middle of the season, as all domestic cup competitions had started in addition to the usual league schedule, which may have had a detrimental effect on acceleration performance. This is a concept which has also been noted in other team sports, such as soccer (7). Additional significant differences were noted for the unilateral CMJ from pre to midseason (ES = 0.67–1.00) and for 505 times (ES = 0.70) from mid to end-season. When viewing the data collectively in Table 2, it is evident that any meaningful differences were a result of performance being worse at the midseason time point, for all tests. Furthermore, when the fixture list of the present sample was considered around midseason, it was clear to see that the players were involved in multiple formats (e.g., county championship and T20

Table 4

Kappa coefficients and accompanying descriptors for the direction of asymmetry between time points, showing levels of agreement in limb dominance.*

Asymmetry metric	Pre-mid	Pre-end	Mid-end
UCMJ:			
Jump height	−0.21 (poor)	0.04 (slight)	0.41 (moderate)
Concentric impulse	0.36 (fair)	0.10 (slight)	0.72 (substantial)
UDJ:			
Jump height	0.34 (fair)	0.34 (fair)	0.33 (fair)
Reactive strength index	0.47 (moderate)	0.72 (substantial)	0.74 (substantial)
COD Speed: 505 & CODD	0.44 (moderate)	0.06 (slight)	0.33 (fair)

*UCMJ = unilateral countermovement jump; CON = concentric; UDJ = unilateral drop jump; RSI = reactive strength index; COD = change of direction; CODD = change of direction deficit.

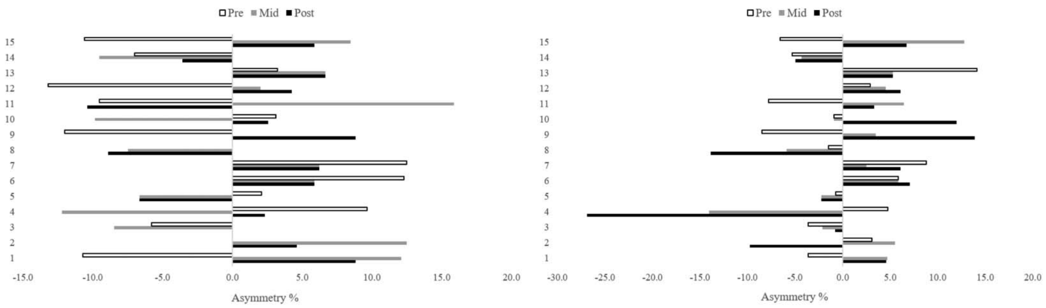

Figure 1. Individual asymmetry values for jump height (left) and concentric impulse (right) during the unilateral countermovement jump test at pre, mid, and end of season. N.B: to the right of 0 indicates right limb dominance and to the left of 0 indicates left limb dominance.

competitions) and had an increase in the number of matches compared with earlier in the season. Although other tests and metrics only experienced significant differences between 2 time points, the 10-m test showed significant differences at each time point, with a large reduction in performance (i.e., slower speeds; ES = −1.39) between pre and midseason. Given the increased volume of matches in midseason, this will have also resulted in reduced time for training, which in turn, would have impacted the ability for players to maintain their preseason acceleration performance. Interestingly, the unilateral drop jump showed no meaningful differences between time points, indicating a somewhat lack of sensitivity in this test to detect changes in test scores throughout the season.

When considering the second aim, the magnitude of asymmetry remained largely consistent for all tests and metrics throughout the season, with only a moderate reduction in asymmetry between mid to end-season for CMJ height (ES = 0.72). A recent study by Bishop et al. (5) found similar results with no significant differences in jump asymmetry across a competitive season in elite academy soccer players. In fact, this study suggested that the mean asymmetry values may provide a "false impression of consistent scores over time" and something similar could be concluded in this study. Table 3 highlights very large *SD* relative to the mean (always >50%), which likely precluded meaningful differences from often being found. This is supported by all ES values (with the exception of one) being trivial to small (ES range = −0.58 to 0.51). Thus, it seems that the magnitude of asymmetry may not be the most viable measure when aiming to comprehend the inherent variability that accompanies mean asymmetry values (2,4,5).

In addition to the magnitude, this study also established levels of agreement for the direction of asymmetry. The kappa coefficient provides an understanding of the proportion of agreement between 2 time points, once any agreement by chance has been removed (10). Put simply, if an athlete favored their right limb at one time point, it enabled us to statistically quantify whether the same limb was favored at another time point and has been used in multiple studies pertaining to asymmetry recently (2–5). This study showed that almost all tests exhibited large amounts of variability in the direction of asymmetry throughout the season, as shown by poor to moderate levels of agreement and is in agreement with recent studies using the same form of analysis for asymmetry (3,5). Interestingly though, kappa values for the unilateral drop jump (especially reactive strength) were noticeably better than other tests, and examination of Figure 2 shows that 73% of the cohort maintained a consistent direction of limb dominance across the season. This has also been found in a recent study using basketball athletes, which determined the consistency of asymmetry in a test-retest design using smartphone apps (3). The direction of asymmetry for jump height (unilateral CMJ) and the 505 COD test, showed kappa values of 0.29 and 0.18, respectively. However, the unilateral drop jump exhibited a kappa value of 0.72, suggesting that the direction of asymmetry was largely consistent between test sessions. Similar findings were found in this study when tracked over time, which may suggest that the unilateral drop jump is a useful test for monitoring consistency in limb dominance (and the direction of asymmetry) throughout a competitive season. Although challenging to fully explain, previous research has highlighted that the drop jump is a more technically demanding task than the CMJ (28)

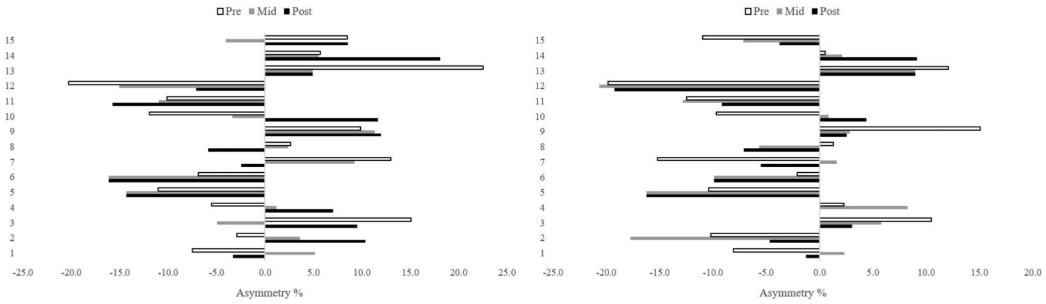

Figure 2. Individual asymmetry values for jump height (left) and reactive strength index (right) during the unilateral drop jump test at pre, mid, and end of season. N.B: to the right of 0 indicates right limb dominance and to the left of 0 indicates left limb dominance.

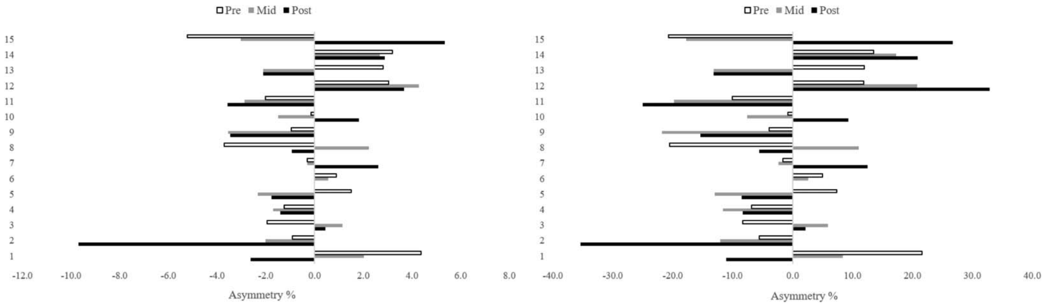

Figure 3. Individual asymmetry values for total time (left) and change of direction deficit (right) during the 505 test at pre, mid, and end of season. N.B: to the right of 0 indicates right limb dominance and to the left of 0 indicates left limb dominance.

and exhibits larger stiffness asymmetries than repeated hopping (25). Thus, the increased complexity and likely increased forces experienced during drop jumps compared with other jump tasks, may make it a harder task for athlete's to manipulate their jump strategy. In turn, this may result in more consistent limb dominance characteristics, when measured between test sessions. It should be noted that this suggestion is only based off thisstudy and one other (3); thus, further research is likely needed to fully corroborate this theory.

There are a number of limitations to this study which must be acknowledged. First, the sample size was small and results can only be attributed to the present cricket club. Second, with this study largely being observational in nature, a more detailed analysis of workload data was not available for this study; thus, changes in performance or asymmetry scores are challenging to fully understand. Future research should aim to establish internal and external workload data, which may provide a more meaningful understanding of why certain tests are more sensitive to change than others. Related to this, our data analysis involved averaging scores before any subsequent analyses that were conducted. Although this method has been used in previous research (4,5,25), such initial analysis prevents interday reliability from being calculated in this study design. This must be acknowledged as limitation because it prevents changes in our data from being interpreted within the context of interday variability. In essence, future research should not only aim to establish whether significant changes are evident for the selected tests but to also determine whether such changes are greater than the associated error in the tests themselves. Finally, prospective research studies which aim to determine whether larger interlimb differences are associated with an increased risk of injury would also be a useful line of investigation, especially in a sport where such limb differences are expected.

Practical Applications

There are 2 key findings from this study which may enhance practitioners' day-to-day practice. First, the 10-m sprint test showed large changes in time throughout the season, so if practitioners are not implementing this test already, it could be worth doing so, as it seems to be a useful performance marker for monitoring change in professional cricket athletes, especially during times of congested fixtures. Second, the magnitude of asymmetry does not seem to differ much between the unilateral CMJ and drop jump tests. However, the direction of asymmetry seems more consistent for the unilateral drop jump test, specifically, RSI; thus, it is suggested that the unilateral drop jump can also be implemented for monitoring asymmetry. That said, practitioners should be mindful of the higher forces experienced during the unilateral version of this test and modify the box height from which athletes start on, to ensure appropriate technique is adhered to for such an advanced test.

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