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Inter-limb Asymmetry Tracking During an Intense Road Cycling Training Camp

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Abstract

It has been proposed that monitoring asymmetry within athletic training programmes may be useful for injury mitigation and/or performance improvement. Within cycling, asymmetry calculation is typically limited to costly on-bike methods. The current study aimed to investigate the usefulness of an off-bike method of asymmetry assessment and assess the reliability of asymmetry calculated on subsequent days during a training camp. Eight semi-professional road cyclists completed an intense 7-day warm weather training camp. Athletes performed single leg countermovement jumps (SLCMJ) to determine inter-limb asymmetry, and scored their daily exercise intensity through rate of perceived exertion and heart rate training stress score. Neuromuscular fatigue was measured through daily countermovement jump height (CMJ). Within-session reliability was good to excellent for SLCMJ, ICC values > 0.83. Mean SLCMJ asymmetry was somewhat variable day-to-day, ranging from 11.72 ± 13.09% (Day 4) to 5.93 ± 6.19% (Day 7). Cohen's Kappa showed a wide range of agreements from slight to substantial (0.06–0.75) for daily comparisons to baseline asymmetry scores. These results show that while measuring asymmetry as part of single day testing can be informative, successive assessment highlights the changeable nature at the individual level, which is not necessarily detectable at the group-level. Practitioners should consider creating individual baseline scores if intending to use asymmetry, which can be time consuming.

Keywords

Bilateral differences; Inter-limb asymmetry; Performance reduction; Athlete monitoring; Imbalance; Road cycling; Race Across America; Tiredness

1 Introduction

Road cycling continues to experience significant growth at both professional and amateur levels. As of 2024, the number of Union Cycliste Internationale (UCI) continental teams has increased by 60% since 2010. Additionally, female participation in road racing has seen a substantial rise, with women now making up 20% of competitive cyclists, up from 8% in 2010, with approximately 760 road world-tour level athletes in 2024 (Union Cycliste Internationale (UCI), 2024). This growth is reflected in the increasing popularity of cycling events and the expansion of cycling infrastructure worldwide (Plămădeală, Goian, & Rusu, 2023) and a global bicycle market increase from 58 billion dollars in 2022 to exceed 82 billion dollars by 2027 (Wang, 2024). With this growth comes an interest in performance measures from the general population, looking for improvements. However, on-bike measurements can become expensive, especially when purchasing for multiple amateur or semi-professional teams with small budgets that still require insights of their performance. A popular example of this is measuring inter-limb asymmetry, which is the concept of comparing the performance or function of one limb in relation to the other (Bini, Rodrigo, Hume, Croft, & Kilding, 2013; Bini, Rodrigo Rico, Nascimento, & Nibali, 2024). Within the cycling academic literature, this has been reported for the purposes of performance improvement (Bini, Rodrigo, Hume, Croft, & Kilding, 2013; Bini, Rodrigo R. & Hume, 2015a; Smak, Neptune, & Hull, 1999; Stefanov, Ivanov, & Aleksieva, 2020) and injury reduction (Bertucci, Arfaoui, & Polidori, 2012; Carpes, Mota, & Faria, 2010; Clarsen, Krosshaug, & Bahr, 2010), through a multitude of costly on-bike methodologies such as power meters mounted in various locations (either both pedals, crank arms, bottom bracket or rear hub), or through laboratory ergometer equipment.

Of these laboratory tests Carpes, Rossato, Mota, & Faria (2006) saw a reduction in asymmetry index (AI% = 0.32±2.92%) using an SRM® bilateral crank dynamometer in the final 10km stage of a simulated 40km road time trial, when compared to stage 1-3 respectively (AI% = 8.91±0.7; 13.51±4.17 and 17.28±5.11%). This seemed to coincide with when power outputs were also significantly higher for all subjects. However, Bini, Jacques, Sperb, Lanferdini, & Vaz (2016) did not see an association between asymmetry and performance in a 20 km simulated road bike time trial using instrumented strain-gauge pedals. Asymmetry index ranged from 43% in favour of the dominant limb to 34% in favour of the non-dominant limb. The association between absolute asymmetry indices and performance time was small ($r=0.01$, $p=0.73$) along with relationship between total pedal force and performance time ($r=-0.32$), $p=0.24$). Within a much shorter simulated time trial of 4 km, Bini & Hume (2015b) observed that asymmetry was associated with faster performances over a 4 km time trial, using a stationary cycling simulator (Computrainer, ProLab 3D, Racermate Inc, Seattle, WA, USA) and surface electromyography. The relationship between asymmetry and performance was strong for effective force ($r = 0.72$). It is evident that there are contradictory results from multiple researchers, using multiple methods of expensive data collection equipment, but little evidence using cost effective field-based metrics such as validated apps or equipment. These articles are useful for exploring performance in a single effort; however, little is known with regards to asymmetry during multiple day intense cycling training camps.

According to Heil, Loffing, & Büsch (2020), exercise-induced fatigue has been identified as a potential factor that can increase the likelihood of injury. This may be due to changes in muscle activation patterns, which can result in altered function, physical capacity, or strength of one limb in relation to the other (Heil, Loffing, & Büsch, 2020). There is limited evidence investigating the consistency of athlete asymmetry scores over time, particularly during training camps designed to induce fatigue for positive physiological adaptations. This investigation aims to examine inter-limb asymmetry in cycling athletes and to assess asymmetry scores in relation to fatigue over a 7-day intensive training camp, utilising field-based testing and affordable data collection methods.

2 Material and Methods

2.1 Experimental Approach to the Problem

To examine the effects of intensive cycle training on inter-limb asymmetry, a repeated measures design was used. Subjects completed 7 days of intensive road cycling training at a warm-weather training camp (average temperature 23-33 degrees centigrade, estimated 2-4 hours training duration per day), with road-specific time trial bikes, specifically prepared for each athlete's physical characteristics and riding style and without power measurement capabilities. Training was classified as 'intensive' by the subjects through external and internal load measures, namely double leg countermovement jumps (prior to daily training), heart rate training stress scores (hrTSS) and Rate of Perceived Exertion (RPE) scale (Subjects updated their training log 30 minutes post training), with data monitored daily via an online training diary (TrainingPeaks, Boulder, United States). Each subject's asymmetry score was assessed prior to daily training via three standardized single leg countermovement jumps performed on the dominant and non-dominant limbs using a contact mat. Bilateral asymmetry was calculated using the formula suggested by Bishop, Read, Lake, Chavda, & Turner (2018). Daily measures were compared to day 1 as the baseline measure, which was undertaken in a non-fatigued state following a standardized warm up.

2.2 Participants

Eight male semi-professional cyclists volunteered to participate in this study (age: 49 ± 6.8; height 165.2 ± 41.8cm, body mass: 81.5 ± 14.1kg); the subjects were winners of the 2019 8-Man Race Across America (RAAM) road cycling event. All subjects attended 100% of the testing sessions, including two familiarization sessions prior to data collection. Heart rate was measured using a Garmin HRM Pro chest strap (Garmin, Olathe, Kansas, United States). Subjects were free from lower limb injury for 6 months prior to study commencement. Before commencement of the study, ethical approval was granted and each participant read and signed a written informed consent form, in accordance with the London Sport Institute Research and Ethics Sub-Committee.

2.3 Procedures

Two weeks prior to data collection, all subjects were familiarized with the performance tests procedure enabling them to practice the double and single leg countermovement jump test for up to 10 trials. During testing, subjects completed the same 10-minute warm-up (Table 1) consisting of a series of multidirectional movements combined with strength exercises and dynamic stretching exercises. This was followed by progressive warm-up attempts for double and single leg countermovement jumps, starting at an estimated 60% effort and increasing in increments of 10% up to 100%.

Table 1. Warm up exercise protocol

Repetitions (each side)	Movement Description
12	Forward Lunges
12	Lateral Lunges
12	Press up position alternate shoulder touches
6	Single leg glute bridges
6	Inchworms
6	Press up position, alternate knee to elbow
15	Forward leg swings
15	Lateral leg swings
15	Alternating calf full range stretch

2.3.1 Double Leg Countermovement Jump Test (CMJ)

In order to track neuromuscular fatigue, subjects were instructed to descend into a countermovement and then rapidly extend both legs to jump as high as possible in the vertical direction (Bishop, Read, Chavda, Jarvis, & Turner, 2019). subjects were instructed to keep their hands in contact with their hips, and for knees to remain extended (but not locked out) on landing. Trials where the participant lost contact with the hips or landed with a knee bend were discounted. Three trials were completed during each testing session and each trial was separated with a 30-second recovery period. The average score of the three trials was calculated and used for statistical analysis (Claudino et al., 2017). Jump height in centimetres was calculated from flight time with a contact mat system (Just Jump System; Probotics Inc., Huntsville, AL, USA), a method demonstrated to have good test-retest reliability (Pueo, Lipinska, Jiménez-Olmedo, Zmijewski, & Hopkins, 2017). A correction equation for Just Jump System from McMahon, Jones, & Comfort (2016) was applied to the resultant data.

2.3.2 Single Leg Countermovement Jump Test (SLCMJ)

The protocol for SLCMJ was completed and analysed using the same parameters as the CMJ, with the alteration of the following: Subjects were instructed to stand on one leg, with swinging of the opposite leg not allowed. Subjects landed on the same leg, absorbing the force as required. Three trials of both dominant and non-dominant legs were completed during each testing session, alternating between legs each trial. Limb dominance was determined by asking the subjects which leg they kick a ball with (van Melick, Meddeler, Hoogeboom, Nijhuis-van der Sanden, & van Cingel, 2017).

2.3.3 Intensity of Training Measurements

Heart rate training stress score (hrTSS) was used to estimate the participant's training intensity over the training camp. hrTSS is widely used in recreational cycling and up to the professional level, mainly due to its link to the most popular training software on the market (i.e., Trainingpeaks.com). It is a way of expressing workload of a training session via pre-determined heart rate training zones and duration. Equation 1 was used for calculating hrTSS:

$$hrTSS = \text{T x} \frac{\text{HRex x IF}}{\text{HR}_{VT2}\ x\ 3600}\ x\ 100$$

Equation (1)

Where T is the duration of the exercise, HRex is the average HR during exercise, IF is the intensity factor calculated from the ratio of HRex to HR_{VT2} and HR_{VT2} is the heart rate at the second ventilatory threshold.

As a subjective measure of internal training load, rate of perceived exertion (RPE) scale was used (CR-10 scale) (Borg, Hassmén, & Lagerström, 1987). The RPE was obtained 30 min after cessation of training and was based on the question: "How hard was your workout?". A score of 6 and above for the training session was deemed to be intense, as the guidelines state that this is classified as between 'hard' and 'very hard' (Hareendran et al., 2012). The participant's weekly mean RPE was then calculated and averaged for a group mean. Training time was measured in minutes per day and used to quantify RPE and hrTSS scores.

2.4 Statistical Analysis

CMJ, SLCMJ, RPE, hrTSS and training time data were exported to Microsoft Excel (Microsoft Corporation, 2018. *Microsoft Excel*), expressed as mean and *SD*. Statistical analysis was then performed using SPSS (Version 26; SPSS Inc., Chicago, IL, USA). A repeated measures (within subjects) analysis of variance (ANOVA) was employed to examine cumulative neuromuscular fatigue, with statistical significance was set at $P < 0.05$, two-tailed hypothesis testing was used with a 95% confidence interval. Shapiro-Wilk test was used to check the normality of the tested parameters. In addition, within-session reliability of the SLCMJ metric were analysed using coefficient of variation (CV) and calculated compared to day 1 measures as a baseline figure (CV: SD [trials 1–3]/ average [trials 1–3] x 100). Inter-limb asymmetries were quantified as a percentage difference between limbs (from the average of 3 trials) using the formula proposed by Bishop, Read, Lake, Chavda, & Turner (2018): Percentage difference: 100/(max value)*(min value)*-1+100. The resultant figure was either a positive or negative value. Negative values were associated with an asymmetry towards the left limb and positive values were associated with an asymmetry towards the right limb. Standard error of measurement was calculated from this data to detect true change over testing error.

A two-way random intraclass correlation coefficient (ICC) with absolute agreement (95% confidence intervals) was calculated for dominant and non-dominant legs from daily mean jump score data. ICC values were interpreted in line with Koo & Li (2016), where scores > 0.9 = excellent, 0.75–0.9 = good, 0.5–0.75 = moderate, and < 0.5 = poor and CV values were considered acceptable if < 10% (Cormack, Newton, McGuigan, & Doyle, 2008). Cohen's Kappa coefficient was calculated to determine the levels of agreement for the size and how consistently an asymmetry favoured the same side; thus, providing the 'direction of asymmetry.' Each day was compared to day 1 baseline, due to this being an unfatigued state versus an increasingly fatigued state. This method was chosen because the Kappa coefficient describes the proportion of agreement between two methods (or in this case testing days) after any agreement by chance has been removed (Cohen, 1960). Kappa values were interpreted in line with suggestions from Viera & Garrett (2005), 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.

Effect size calculated using Cohen's d_s with Hedge's g_s correction factor for small groups (Lakens, 2013) was applied to the daily changes in group mean SLCMJ heights and asymmetry scores without direction. This was used to determine the magnitude of change from day 1 baseline data and thus determining how fatigue effects jump height and asymmetry. Effect sizes were calculated as per Equation 2 and interpreted according to Hopkins (2004), with subjects being classed as "highly trained", whereby < 0.25 = trivial; 0.25 – 0.5 = small; > 0.5 – 1.0 = moderate; > 1.0 = large. Statistical analysis was conducted using SPSS version 26 with the level of significance set at $p < 0.05$.

$$\text{Hedges } g_s = \text{Cohen's } d_s \times \left(1 - \frac{3}{4(n_1 + n_2) - 9}\right)$$

Equation (2)

Standard error of measurement (SEM) was used to evaluate actual change versus test error. Actual change was determined by being larger than the SEM.

3 Results

All data were normally distributed ($p > 0.05$) and within session reliability data can be viewed in Table 2. All tests reported "good" to "excellent" reliability (ICC = 0.83-0.97) and acceptable variability (CV $\leq$7.61%). Intensity of training measures provided a mean weekly hrTSS of 802.3±107.5, mean weekly RPE of 6±0.5 relating to "hard/very hard" on the RPE 10-point scale, reported in Figure 1. Mean daily training time was 191±63.8 minutes during 7 consecutive days of training. This data includes 1 day of lower intensity effort, classified as a recovery/regeneration day, hence the standard deviation in hrTSS, RPE scores and training time.

Mean weekly CMJ was 28.56±4.86cm, daily data shown in Figure 2. Mauchly's test of sphericity indicated that the assumption of sphericity was met, $X^2(20)=31.35$, p=0.072. CMJ test for neuromuscular fatigue elicited statistically significant changes in jump height over time $F(6,54) = 6.522$, $p < 0.001$, partial $\eta^2 = 0.420$. Post hoc analysis with a Bonferroni adjustment revealed that CMJ height was statistically significantly decreased from Day 1 (29.45 ±4.93cm) to Day 5 (26.10 ± 4.72cm) (0.39 (95% CI,-3.48-4.26)cm, $p < 0.035$) but not at any other time point, indicating neuromuscular fatigue was achieved during the training camp.

Considering whole-group analyses, "small" effect sizes (d = 0.29 to 0.40) suggested greater SLCMJ heights for the non-dominant limb for days 4-7 versus baseline, whilst dominant limb SLCMJ heights were greater on days 4-5 (d = 0.25 to 0.38) versus baseline. Mean SLCMJ asymmetry was somewhat variable from day-to-day, ranging from 11.72 ± 13.09% (Day 4) to 5.93 ± 6.19% (Day 7).

Table 2. Mean performance data ± *SD*, within-session reliability data and asymmetry data with effect sizes in comparison to baseline for Single Leg Counter Movement Jumps, dominant and non-dominant sides.

DAY	SLCMJ ND (cm)	SLCMJ D (cm)	ICC (95% CI) ND	ICC (95% CI) D	CV (%) ND	CV (%) D	Effect Size SLCMJ ND (95% CI)	Effect Size SLCMJ D (95% CI)	Asymmetry (%)	Effect Size Asymmetry (95% CI)
1	14.51 ± 3.19	14.81 ± 4.17	0.88 (0.66, 0.97)	0.90 (0.71, 0.98)	7.64	7.03	BASELINE	BASELINE	10.87 ±11.72	BASELINE
2	15.13 ± 3.60	15.44 ± 3.74	0.92 (0.71, 0.98)	0.89 (0.69, 0.97)	6.08	6.42	-0.17 (-1.25, 0.90)	-0.15 (-1.22, 0.92)	8.46 ± 9.43	0.08 (-1.00, 1.15)
3	15.20 ± 3.64	15.48 ± 3.66	0.97 (0.88, 0.99)	0.93 0.78, 0.98)	4.36	6.34	-0.19 (-1.27, 0.89)	-0.16 (-1.23, 0.91)	8.73 ± 8.79	0.16 (-0.91, 1.24)
4	15.89 ± 3.30	15.90 ± 4.18	0.89 (0.71, 0.97)	0.87 (0.65, 0.97)	6.24	7.28	-0.40 (-1.49, 0.68)	-0.25 (-1.32, 0.83)	11.72 ± 13.09	0.26 (-0.82, 1.33)
5	15.61 ± 2.84	16.38 ± 3.58	0.87 (0.65, 0.97)	0.88 (0.66, 0.97)	5.89	6.70	-0.34 (-1.43, 0.74)	-0.38 (-1.46, 0.70)	10.95 ± 5.22	-0.07 (-1.14, 1.00)
6	15.86 ± 2.93	15.54 ± 3.60	0.89 (0.70, 0.97)	0.95 (0.84, 0.99)	7.42	6.23	-0.42 (-1.50, 0.67)	-0.18 (-1.25, 0.90)	5.93 ± 6.19	0.20 (-0.88, 1.27)
7	15.48 ± 3.00	14.98 ± 4.05	0.90 (0.71, 0.98)	0.83 (0.55, 0.96)	7.18	9.47	-0.29 (-1.37, 0.78)	-0.04 (-1.11, 1.04)	9.68 ± 8.36	0.54 (-0.56, 1.63)

SLCMJ = single leg countermovement jump; D = dominant leg; ND = non-dominant leg; ICC = Intraclass correlation coefficient; CI = Confidence intervals; CV = Coefficient of variation; cm = centimetres.

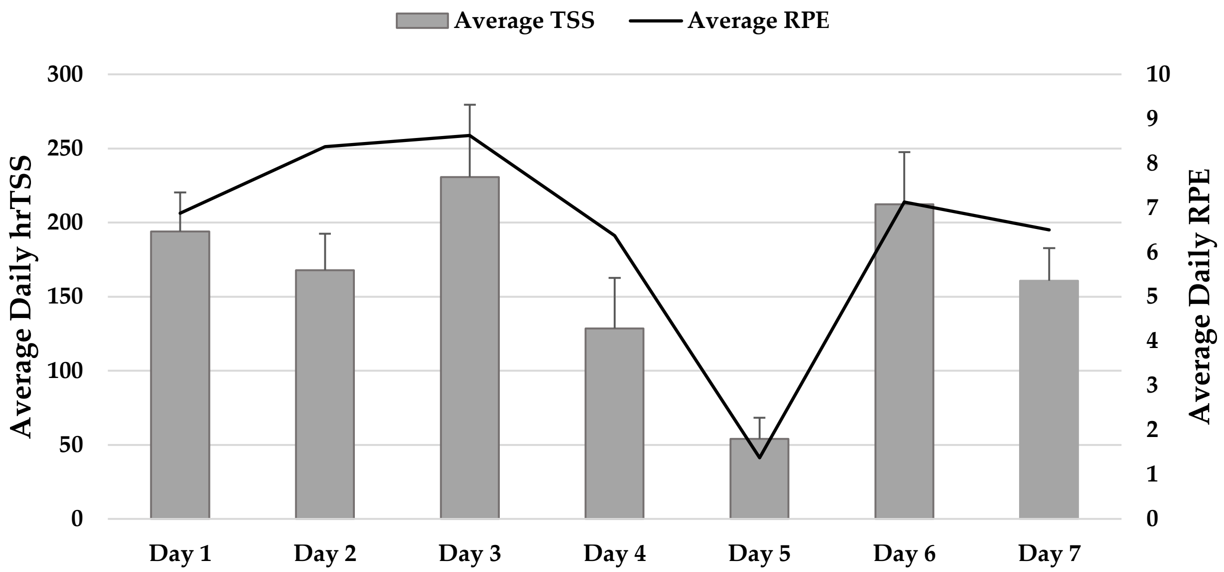


Figure 1. Heart Rate Training Stress Score and Rate of Perceived Exertion data

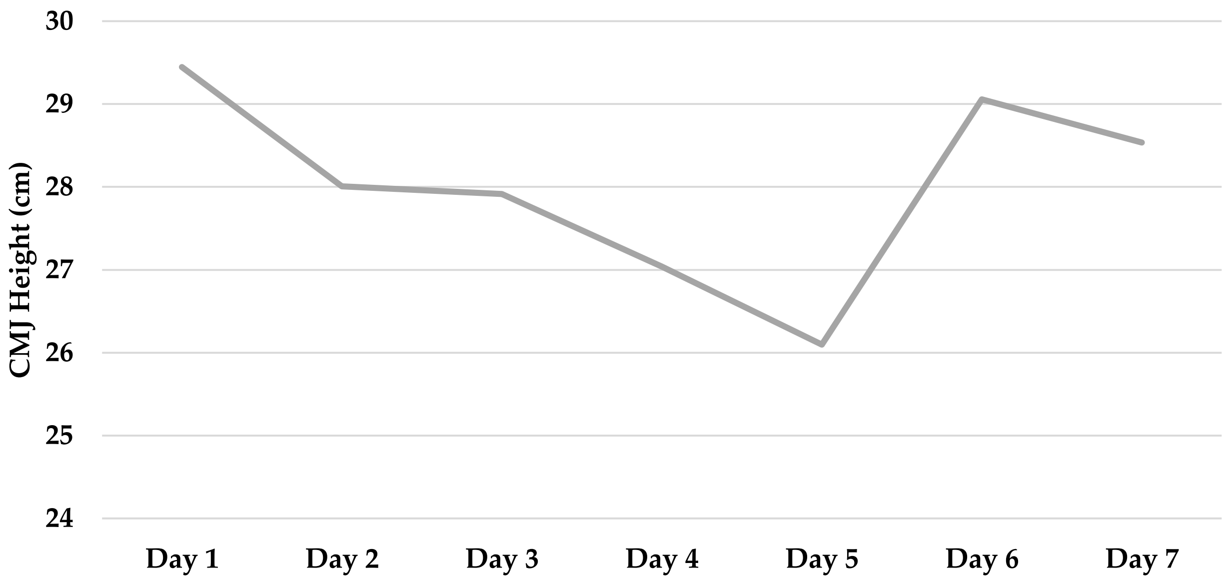


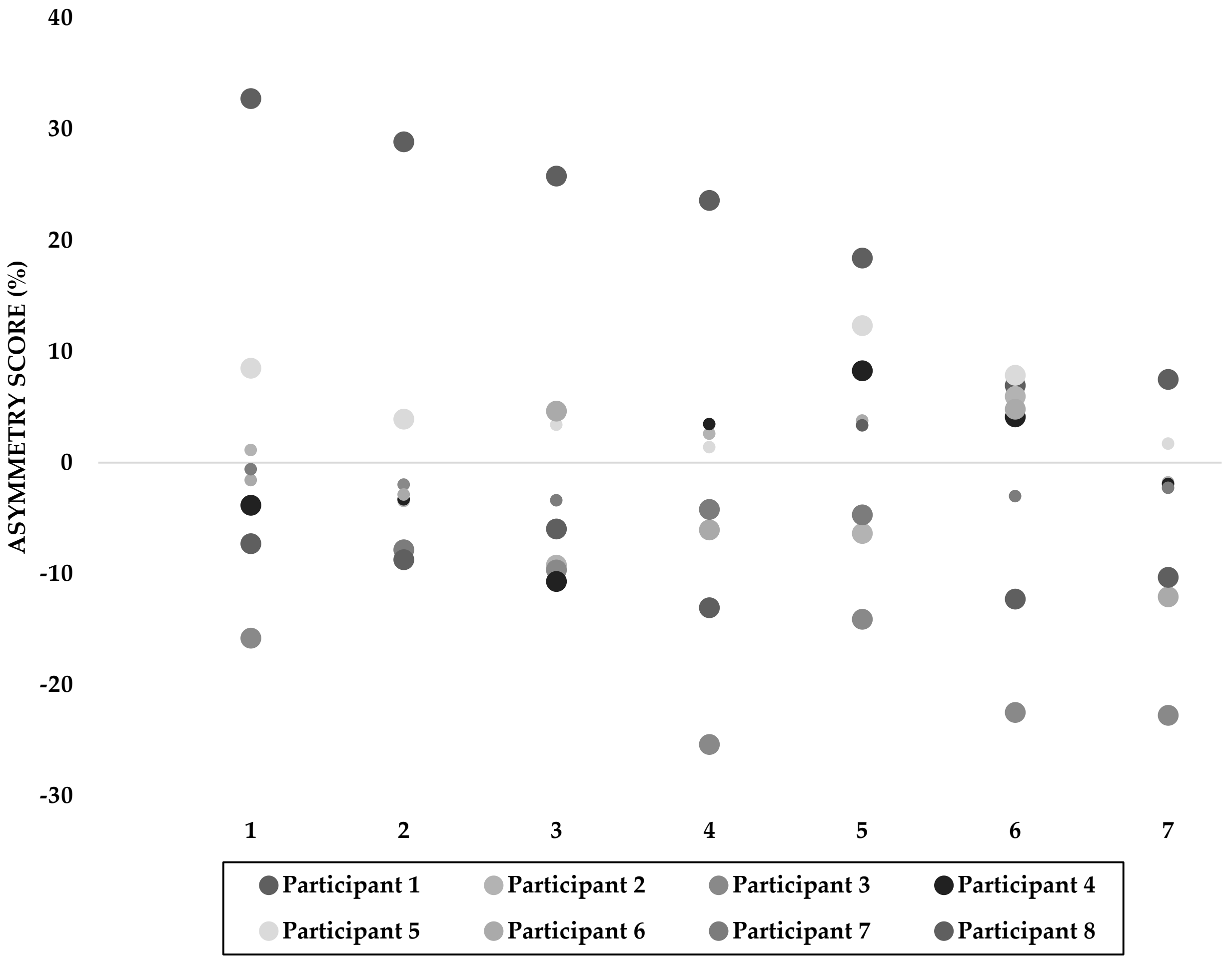
Figure 2. Daily Average Countermovement Jump data.

Individual asymmetry analysis identified 19% of scores involved an asymmetry changing from the baseline dominant to non-dominant limbs throughout the testing period (Figure 3). Levels of agreement for asymmetry scores were calculated using Cohen's Kappa coefficient and are shown and described in Table 3. Results showed a wide range of agreements from slight to substantial (range = 0.059 – 0.750) for daily comparisons to baseline scores.

Table 3. Kappa values and descriptive levels of agreement between daily individual asymmetry scores in comparison to day 1 baseline data.

	Kappa Coefficient	**Level of Agreement**
Day 1 v Day 2	0.71	substantial
Day 1 v Day 3	0.47	moderate
Day 1 v Day 4	0.75	substantial
Day 1 v Day 5	0.06	slight
Day 1 v Day 6	0.53	moderate
Day 1 v Day 7	0.71	substantial

Figure 3. Subjects' individual asymmetry scores with direction recorded daily over 7 days of training.



Standard error of measurement = ± 3.71. Statistically significant changes are those outside the calculated standard error of measurement, denoted by a larger point.

4 Discussion

The aim of the study was to examine inter-limb asymmetry via cost-effective, methods within road cycling athletes and assess any change in individual asymmetry scores as fatigue increased over the course of a training camp. The purpose was to determine the ability to use these metrics to aid with real-world coaching and programming for in-the-field scenarios. Results indicated that the training stimulus was effective at producing high levels of intensity and exertion, as demonstrated through internal and external load measurements (Table 2, Figure 1). Analysis of daily CMJ testing for neuromuscular fatigue revealed statistically significant change in jump height in comparison to baseline at day 5, which indicates neuromuscular fatigue was achieved. Group-mean data revealed little change in asymmetry scores over the course of the training camp, despite substantial standard deviations. However, individual data viewed on a day-to-day basis indicated substantial variability, thus highlighting the extremely variable nature of asymmetry.

Whilst group-mean changes in SLCMJ asymmetry scores were not significant from day-to-day, SLCMJ jump heights did appear to exhibit changes. Thus, it is perhaps more pertinent to consider changes in these 'raw' metrics directly, as opposed to the asymmetry values which is calculated only as a ratio based upon these raw values. The data indicated a weekly mean percentage change of 12.77% (±7.41%, CV = 6.20%) for the dominant limb and 13.64% (±10.06%, CV = 7.41%) for the non-dominant limb. CV analysis demonstrates that this change is above test error, therefore should be considered as a meaningful change. Effect size analysis demonstrated small to moderate magnitude of change (ES = 0.33-0.51) for the non-dominant limb compared to baseline, however a much smaller range (trivial to small) within the dominant limb (ES = -0.05-0.40). Interpretation of this data may mean that the non-dominant limb is more sensitive to change than the dominant limb, which agrees with previous research (Radzak, Putnam, Tamura, Hetzler, & Stickley, 2017; Zifchock, Davis, Higginson, McCaw, & Royer, 2008). This may account for changes in asymmetry score as the camp progresses due to raw jump data being used in the ratio calculation for asymmetry scoring. Interestingly, the ES data provides a useful insight that the non-dominant limb was more affected and could provide a training insight to be considered for future programming.

Trivial magnitude size changes were recorded from effect sizes of asymmetry scores, in comparison to the baseline measure (*ES* = -0.07–0.54). However, the large standard deviations infer that there are wide-ranging scores recorded by each subject that are seemingly undetected once the data is grouped and a mean-value calculated. This is becoming a common theme within inter-limb asymmetry studies and has been reported for a range of age groups and sports (Bell, Sanfilippo, Binkley, & Heiderscheit, 2014; Bishop et al., 2021b; Fort-Vanmeerhaeghe, Gual, Romero-Rodriguez, & Unnitha, 2016; Guan et al., 2021). This justifies the analysis of data at the individual level, which is in line with previous research by Bishop et al. (2021a). Due to the group size, it is possible to present this data effectively within this study. To determine the usefulness of the individual data, Table A1 (see appendix 1) depicts each subject's daily asymmetry score relative to their CV. The results indicate that individual asymmetry testing is generally sensitive to determine daily changes for each athlete. Furthermore, it also reveals the large ranges in individual's CV scores that group mean data is unable to detect. Overall, the CV being a smaller value than the asymmetry score indicates that these changes are above the relative variability of testing and are therefore a true change, not due to testing error. However, in the current data set, there were instances where the CV was unacceptable at certain timepoints, particularly at baseline, for certain individuals. This highlights the possibility of identifying where it would be important to work with individual athletes to improve their consistency within the testing process.

Compared to baseline, Kappa statistics showed a wide range of agreements from slight to substantial (0.06–0.75) for daily comparisons to baseline asymmetry scores. In this study, the testing stays the same, however due to the intensive nature of training, the daily testing results may differ due to increased levels of fatigue or possible potentiation effects on the neuromuscular system. As the study aimed to determine how common it was for asymmetries to favour same limb each day, Kappa values highlight slight to substantial levels of agreement. For example, if an asymmetry favoured on the right limb during day 2, it was likely that the right limb was not favoured the following day. It is pertinent to bear in mind that the Kappa statistic removes the possibility that this agreement may have occurred due to chance (McHugh, 2012). Interestingly, the day with the least agreement (i.e., the day when most subject's asymmetry was furthest away from their baseline measure) occurred on the morning of the recovery day (day 5). This was following three days of intensive training (see figure 1) and demonstrates that it is possible to use the Kappa metric to evaluate the changing nature of asymmetry in association with fatigue. Following a low intensity training day (and therefore enhanced recovery) the kappa agreement returned to a moderate agreement, demonstrating sensitivity in this regard. If measuring asymmetry over time, this method of analysis may be effective for the scientist or practitioner to consider.

5 Conclusions

Inter-limb asymmetries in cycling may reduce the performance and increase the injury incidence of athletes. Importantly, this study highlights that inter-limb asymmetry testing should be completed regularly to build a consistent picture of an individual athlete's performance, which can be time consuming. Basing a training strategy or intervention following a single testing session may lead to unnecessary training prescriptions, therefore data should be treated with caution. Further research is required to establish relationships between on-bike and off-bike measures of inter-limb asymmetry.

6 Limitations

Despite the aforementioned results, readers should be aware of the study's limitations. Firstly, it is important to point out that the subjects involved are cyclists, and the test metric used were single leg countermovement jumps (SLCMJ) using a switch mat. Although jump training was a part of the athlete's weekly strength programming, on-bike testing using a power meter to measure differences between limbs may have been more appropriate. It is therefore possible that some learning effect may explain the small increases in SL CMJ height which were observed over the training camp. Due to the costly nature of such devices for each participant's bike, it was not possible to gather such data and force plate data was not possible due to airline luggage restrictions travelling to the data collection site.

Supplementary Materials: The following are available online at www.jsc-cycling.com/xxx, Figure S1: title, Table S1: title, Video S1: title.

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Appendix 1

Table A1. Individual asymmetry score in relation to the subject's CV.

	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7	
	Asymmetry	**%CV**	**Asymmetry**	**%CV**	**Asymmetry**	**%CV**	**Asymmetry**	**%CV**	**Asymmetry**	**%CV**	**Asymmetry**	**%CV**	**Asymmetry**	**%CV**
Subject 1	34.13	29.10	29.05	24.03	29.03	24.01	34.80	29.80	12.06	9.08	9.14	6.77	9.47	7.03
Subject 2	2.04	1.46	1.69	1.21	8.33	6.15	0.81	0.57	5.51	4.01	2.52	1.81	4.95	0.57
Subject 3	21.43	16.97	1.12	0.80	1.10	0.78	28.91	23.89	18.70	14.59	17.70	13.73	26.61	23.89
Subject 4	12.35	9.31	3.80	2.74	5.43	3.95	5.23	3.80	6.21	4.54	1.68	1.20	0.57	3.80
Subject 5	2.40	1.71	6.81	4.98	2.94	2.11	4.59	3.32	15.30	11.72	2.98	2.14	10.05	3.32
Subject 6	3.73	2.69	3.43	2.47	7.36	5.40	2.56	1.84	8.28	6.11	0.00	0.00	15.15	1.84
Subject 7	0.60	0.42	5.85	4.26	4.43	3.21	3.23	2.32	5.71	4.16	2.00	1.43	1.51	2.32
Subject 8	10.29	7.67	15.92	12.23	11.18	8.37	13.64	10.35	15.85	12.18	11.46	8.60	9.09	10.35