Vertical and Horizontal Asymmetries are Related to Slower Sprinting and Jump Performance in Elite Youth Female Soccer Players

ABSTRACT

Inter-limb asymmetries have been shown to be greater during vertical jumping compared to horizontal jumping. Notable inter-limb differences have also been established at an early age in male youth soccer players. Furthermore, given the multi-planar nature of soccer, establishing between-limb differences from multiple jump tests is warranted. At present, a paucity of data exists regarding asymmetries in youth female soccer players and their effects on physical performance. The aims of this study were to quantify inter-limb asymmetries from unilateral jump tests and examine their effects on speed and jump performance. Nineteen elite youth female soccer players performed a single leg countermovement jump (SLCMJ), single, triple, and crossover hops for distance and a 20 m sprint test. Test reliability was good to excellent (ICC = 0.81-0.99) and variability acceptable (CV = 1.74-5.42%). A one-way ANOVA highlighted larger asymmetries from the SLCMJ compared to all other jump tests ($p < 0.05$). Pearson's correlations portrayed significant relationships between vertical asymmetries from the SLCMJ and slower sprint times ($r = 0.49$-0.59). Significant negative relationships were also found between horizontal asymmetries during the triple hop test and horizontal jump performance ($r = -0.47$ to -0.58) and vertical asymmetries during the SLCMJ and vertical jump performance ($r = -0.47$ to -0.53). The results from this study highlight that the SLCMJ appears to be the most appropriate jump test for identifying between-limb differences with values ~12% showing negative associations with sprint times. Furthermore, larger asymmetries are associated with reduced jump performance and would appear to be direction-specific. Practitioners can use this information as normative data to be mindful of when quantifying inter-limb asymmetries and assessing their potential impact on physical performance in youth female soccer players.

Key Words: Symmetry, speed decrements, jump performance, youth athletes

INTRODUCTION

The notion of inter-limb asymmetries refers to the function of one limb in respect to the other and has been a popular source of investigation in recent years. The majority of literature has focused on the prevalence of between-limb differences in multiple testing modalities such as isokinetic dynamometry (14,37), isometric squat or mid-thigh pulls (16,19), back squatting (30,38), and a variety of jumping-based tasks (3,12,27,28). All of the aforementioned methods have been shown to be sensitive when identifying differences between limbs in both athlete and non-athlete populations. Furthermore, it has been stated that inter-limb asymmetries may be a product of the time spent competing in the same sport (18,20). However, their prevalence alone provides limited information as to whether targeted training interventions may be required to minimise their presence. Consequently, understanding whether inter-limb asymmetries have a detrimental impact on physical performance would provide practitioners with more tangible information pertaining to their importance.

Jump protocols are a common modality for testing in youth soccer athletes (11,26,32,41,43), most likely because of their ease of implementation (9) which is an important consideration due to the reduced training age in youth athletes. This is supported by Read et al. (31) who suggested that jump tests not only offer a viable method of quantifying inter-limb asymmetries, but that many have successfully been used to prospectively identify athletes at risk of injury (2,22,35). It was also suggested that unilateral jump tests may be the preferred option when quantifying inter-limb differences due to their enhanced sensitivity for detecting differences (10), which in part may be due to the heightened instability associated with single leg tests. Additional literature has acknowledged that no contribution exists from the opposing limb during unilateral tests; therefore, representing a more accurate interpretation of ‘true asymmetries’ (4,9). In addition, because the relationship between multi-planar demands of soccer and different jumping tasks is still unclear (21,28), more than one test should be used to assess asymmetries.

Consequently, many unilateral jump tests have been incorporated in the literature to date. Single leg countermovement jumps (SLCMJ) and single, triple, and crossover hops for distance have all displayed strong reliability (ICC range = 0.89-0.99) (10,34,36); thus, practitioners can be confident of their consistency during testing. Dos'Santos et al. (15) recently reported that asymmetries during single and triple hops for distance were not associated with slower change of direction speed times. However, the largest imbalance reported can be considered small (6.25%), with larger deficits (≥ 10%) potentially impacting performance (7). Read et al. (33) investigated the effects of maturation on inter-limb asymmetries using the SLCMJ and single leg hop for distance in elite youth male soccer players. They found that SLCMJ landing forces were significantly higher in those who were circa and post-peak height velocity (PHV). Asymmetries during the single leg hop for distance were small, but reduced even further with age. Although useful, the aforementioned evidence relates to male youth players and currently a paucity of data exists concerning youth female soccer players. Thus, the quantification of inter-limb asymmetries from unilateral jump tests and their relationship with physical performance would be a useful addition to the literature for youth female athletes.

Therefore, the primary aim of this study was to assess the relationship between jumping asymmetries and sprint and jump performance in elite youth female soccer players. This could help to determine whether training interventions might be necessary to rectify existing side-to-side differences. A secondary aim was to quantify inter-limb asymmetries from multiple unilateral jump tests in order to provide an asymmetry profile that is currently lacking in elite youth female soccer players.

METHODS

Experimental Approach to the Problem

After a separate habituation session, data were collected during a single session. The first session allowed players to practice all tests an unlimited number of times until the requirements were fully understood. During data collection, multi-planar jump tests were used to quantify inter-limb asymmetries to represent ecological validity for the population in question, whilst four sets of timing gates were used over 20 m. This enabled split times to be measured for 5, 10, and 20 m sprints and subsequently, multiple relationships to be assessed between asymmetry scores and sprint and jump performance. In addition, test variability was quantified using the coefficient of variation (CV), noting that inter-limb differences are only considered 'real' if greater than test variability (17).

Subjects

Nineteen elite youth female soccer players (age: 10 ± 1.1 years; height: 141 ± 7.9 cm; body mass: 35 ± 7.1 kg), were recruited from a Tier 1 Regional Talent Centre (RTC) of a professional soccer club. Players trained for at least 36 weeks per year and were required to take a minimum of 2 x 30-minute structured strength and conditioning training sessions per week. Emphasis at this age was placed on mastering fundamental movement patterns, building strong foundations, enhancing technical competency, and improving general motor control. All subjects were free from injury at the time of testing and informed consent and PAR-Q forms were completed from all relevant parents or guardians as all participants were under the age of 18. Ethical approval was granted from the London Sports Institute ethics committee, Middlesex University.

Procedures

Subjects were tested at the same time of day on two separate testing occasions, each separated by 72 hours. Session one was used to familiarize all subjects with the test procedures, enabling them to practice each jump and sprint test as many times as they wanted; although all players were instructed to practice each test a minimum of five times. The second session was used for data collection and during the jump tests; a particular emphasis was placed on landing mechanics, owing to the increased demand of having to land on one limb. All participants were asked not to participate in any strenuous exercise at least 24 hours prior to testing, and to ensure they wore the same footwear on each occasion to negate the effects of different shoe design and support structures. Both sessions took place on a third generation (3G) pitch, which subjects were used to training on twice weekly. Each jump test consisted of three trials on each limb with 60 seconds rest between trials, and 2-minutes rest between tests, in order to allow for full recovery (34). All tests were conducted in a randomized, counter-balanced order, so as to negate any potential learning effects. Prior to familiarization and testing sessions, all participants completed a standardized warm-up protocol, following the RAMP system as outlined by Jeffreys (23). This consisted of dynamic stretches such as multi-planar lunges, inchworms, and spiderman exercises before progressing into practice jumps and sprints at 60, 80, and 100% of perceived maximum effort. A 3-minute rest period was prescribed between the warm up and the first test.

Single leg countermovement jump (SLCMJ). Subjects stood in an upright position, hands on hips, with feet positioned hip width apart. To begin the test, one leg was lifted off the floor to approximately mid shin height of the standing leg. Subjects then performed a countermovement to a self-selected depth followed by a quick upward vertical movement, triple extending at the ankle, knee, and hip with the intention of jumping as high as possible. The jumping leg had to remain fully extended and hands fixed to hips; any deviation from this required the trial to be re-taken after a 60-second rest period. Jump height was calculated by the flight time method using the “My Jump” iPhone application, which has been shown previously to be a reliable method (1).

Single leg hop (for distance). Subjects begin by standing on the designated testing leg with their hands on hips and their toes behind the starting line. Subjects were then instructed to hop as far forward as possible and land on the same leg. Upon landing, participants were required to ‘hold and stick’ their position for two seconds. Failure to stick the landing resulted in a void trial and the jump being retaken after a 60-second rest. This was consistent across all trials for all hop tests. The distance hopped from the starting line to the point where the subject’s landing heel hit in the final position was then recorded to the nearest centimetre using a standard measuring tape fixed to the floor (also used for all hop tests).

Triple hop (for distance). Subjects begin by standing on the designated testing leg, hands on their hips with their toes behind the starting line. Subjects were instructed to take three maximal hops forward (landing on the same leg throughout) with the intention of minimising ground contact times after the first and second hops. When landing from the final hop, subjects were required to ‘stick’ the landing and hold for two seconds. Failure to stick the final landing resulted in a void trial and the jump being retaken after a 60-second rest. The distance hopped from the starting line to the landing position of the subjects’ heel was then measured and recorded to the nearest centimetre.

Crossover hop (for distance). Subjects began by standing on the designated testing leg, with their toes behind the starting line. If subjects were hopping with their right leg, they started the test on the right side of the measuring tape and vice versa if they started on the left leg.

Subjects were instructed to take three consecutive maximal hops forward; each time crossing over an area measuring 15 cm wide landing on the same leg throughout. As per previous hop testing protocols, all subjects were required to stick the final landing for two seconds. Failure to do so resulted in a void trial and the jump being retaken after a 60-second rest. The distance hopped from the starting line to the point where the subject's heel hit on completion of the third jump was measured and recorded to the nearest centimetre.

5, 10, and 20 m Sprints. Electronic timing gates (Brower Timing Systems, Utah, USA) were positioned at 0, 5, 10, and 20 m to enable multiple splits to be measured during a single sprint. Subjects 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 prior to the initiation of the test. When ready, subjects sprinted through the final set of timing gates allowing for 5, 10, and 20 m split times which were recorded to the nearest hundredth of a second.

Statistical Analyses

All data was initially computed as means and standard deviations (SD) in Microsoft Excel™ and all additional analyses computed in SPSS (SPSS Inc., Chicago, IL, USA). All data were checked for normality using the Shapiro-Wilk test and within-session reliability of test measures were computed using intraclass correlation coefficient (ICC) with absolute agreement and the CV. Interpretation of ICC values was in accordance with previous research by Koo and Li, (24) where values > 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% (13,40). Inter-limb asymmetries were quantified as the percentage difference between the two limbs (see Equation) rather than using a reference value for limb dominance as has been previously suggested (5,6). A one-way analysis of variance (ANOVA) was used to examine for potential differences in asymmetry between jumping tasks with statistical significance set at $p < 0.05$. Pearson's r correlation was utilised to determine the strength of the relationship between asymmetries measured during each jump test and sprint times, and between asymmetry scores and jump performance with statistical significance set at $p < 0.05$.

Equation: 100/Max Value (right and left)*Min Value (right and left)*-1+100 (6)

RESULTS

All data were normally distributed ($p > 0.05$) and each test had acceptable between trial consistency with all CV values < 10%, and good or excellent ICC's (Table 1). Mean asymmetry values are presented in Table 1 and the SLCMJ showed greater ($p < 0.05$) side-to-side differences (approximately double) compared to all other jump tests. Correlations between jump tests/asymmetries and sprint tests are shown in Table 2 and correlations between asymmetries and jump performance in Table 3. Results indicated that larger vertical asymmetries were associated ($p < 0.05$) with slower sprint times (Table 2). Asymmetries during the triple hop test were associated ($p < 0.05$) with reduced horizontal jump performance and vertical asymmetries were associated ($p < 0.05$) with reduced vertical jump performance (Table 3). Individual asymmetry data have also been included (Figures 1-4).

*** INSERT TABLES 1-3 ABOUT HERE ***

*** INSERT FIGURES 1-4 ABOUT HERE ***

DISCUSSION

The aims of this study were to test for the presence of asymmetries during vertical and horizontal jump tests in elite youth female soccer players and examine relationships between asymmetries measured in these different tasks and sprint and jump performance. Results indicated that asymmetry is task-dependent as the SLCMJ produced significantly greater between-limb differences compared to all horizontal hop tests. Significant relationships were also present between asymmetries in the SLCMJ and sprint times measured across distances of 5, 10, and 20 m. No significant relationships were found between asymmetries during horizontal hop tests and any of the sprint distances measured. Significant negative relationships were also found for horizontal asymmetries in the triple hop test and horizontal jump performance, and asymmetries in the SLCMJ and vertical jump performance.

The first point to consider from these results is that the SLCMJ produced significantly greater asymmetries than all other jump tests which is in agreement with previous research. Lockie et al. (25) reported asymmetries of 10.4 and 5.1% during the SLCMJ and single leg broad jump respectively (also called single leg hop for distance). It is possible that vertical jumping may be more sensitive at identifying asymmetries given that the results in the present study and that of Lockie et al. (25) found inter-limb differences ~50% greater than any horizontal jump test. Furthermore, the sample used in Lockie's study were adult male team sport athletes and with a similar trend now found in the present study (from a completely different sample), these results require an explanation. Intuitively, this seems quite difficult to fully explain; however, considering children learn and practice horizontal hopping activities (such as hop scotch) from an early age (39,42), it could be argued that these movement patterns are practiced more than unilateral vertical jumping for youth athletes. This may explain why inter-limb differences are notably less in horizontal jumping tasks; however, further research is still warranted to fully corroborate this theory.

In addition to significantly larger inter-limb differences from the SLCMJ, this was the only asymmetry that had significant correlations with sprint times (Table 2). Furthermore, all *r* values from the SLCMJ asymmetry scores are positive, indicating that larger asymmetries may be indicative of slower sprinting; noting that the fastest time is always desirable in sport. Consequently, practitioners who measure between-limb asymmetries from jump tests should be mindful of differences ~12% and aim to quantify whether they are associated with any decrements in performance. This seems prudent advice given the notion that asymmetries > 10% have been suggested to potentially impact physical and sports performance (7,9) and the results of the present study are in agreement with this consensus. Cumulatively, given that the SLCMJ appears more sensitive at identifying inter-limb differences and shows stronger relationships to decrements in sprint speed compared to horizontal hops, these results indicate that the SLCMJ may be the most appropriate jump test to identify the prevalence of inter-limb asymmetries in athletes.

When examining the role of inter-limb differences on jump performance, the results show interesting findings (Table 3). Firstly, asymmetries from the triple hop test were significantly associated with reduced performance in all horizontal jump tests, but no significant correlations were found with the SLCMJ. In addition, asymmetries from the SLCMJ were also significantly associated with reduced jump performance during vertical jumping only. Recent literature has indicated that determinants of unilateral jump performance are direction-specific (29), and it would appear that asymmetries may follow this trend as well. Although anecdotal, it seems logical to assume that if asymmetries are minimised during unilateral tests that jump performance may also improve (in the same direction). Given that no contribution exists from the non-jumping leg during unilateral tests (9), a larger asymmetry will naturally result in one limb performing poorly in respect to the other. What is apparent from the present study is that horizontal jumping appears unaffected by vertical asymmetries, and vice versa. Thus, with inter-limb differences being direction-specific, it is suggested that soccer practitioners consider monitoring asymmetries in multiple directions (9,31) with a view to reducing these differences to potentially enhance jump performance.

A further consideration relates to the individual nature of asymmetries. Firstly, it is interesting to note that the single effort tests showed the greatest individual variation in asymmetry scores (SLCMJ range = 0.0-36.4%; single leg hop range = 0.7-25%) compared to the repeated effort tests (triple hop range = 0.3-14.2% and crossover hop range = 0.6-11.7%) (Figures 1-4). Previous research has highlighted that the single leg hop is able to detect larger asymmetries than other commonly used alternatives such as the triple hop or crossover hop tests (35). Thus, it is plausible that between-limb differences may 'even out' during repeated efforts by virtue of momentum being built throughout the test, although further research is again required to fully corroborate this theory. In addition, there was variation in the direction of asymmetry across tests for individual subjects (Figures 1-4). It is worth noting that this too appears to be test-specific with only two subjects demonstrating larger scores on the same leg for each test. This further highlights the individual nature of asymmetries and the requirement for multiple tests (9,31) in order to better understand their prevalence and interaction with physical performance.

When measuring asymmetries, practitioners should also be mindful of the scores in relation to test variability (CV). Exell et al. (17) suggest that asymmetries can only be considered real if inter-limb differences are greater than the variability during test protocols. In the present study, all CV values were < 10% which is considered acceptable (13) and with each jump test demonstrating a greater asymmetry score than the CV, these between-limb differences can be considered real. Despite the prevalence of these asymmetries, it should be reiterated that only differences in the SLCMJ were associated with sprint decrements; thus, their reduction could be considered a viable aim during targeted training interventions. Furthermore, additional factors such as technique and strength may be more prominent reasons why sprint decrements exist (43); thus, coaches should consider the relevance of these when aiming to optimise sprint performance.

When interpreting the findings of the current study, practitioners should be mindful of some limitations. Firstly, these results are only applicable to youth female soccer players and future research should aim to provide comparisons across gender and sports where possible. In addition, the impact of jumping asymmetries on physical performance metrics should be investigated across multiple age groups in youth female athletes; thus, highlighting the impact that maturation may have. Read et al. (33) noted that landing force asymmetries during the SLCMJ increased during maturation, but asymmetries in distance from the single leg hop test actually decreased, and it would be useful to consider these results across multiple age groups in female athletes.

PRACTICAL APPLICATIONS

Unilateral jump tests are easy to administer and ecologically valid, especially for team sport athletes. The SLCMJ appears to be the most appropriate test for identifying inter-limb asymmetries in youth female soccer players and these differences are associated with slower sprint times. Consequently, practitioners should be mindful of between-limb differences > 10% considering the impact this may have on physical performance. This threshold may be used cautiously to determine if training interventions are deemed necessary for the reduction of asymmetry. Currently, little is known about strategies for the reduction of asymmetries; however, recent literature highlighted that a combination of bilateral and unilateral strength and jump training will likely assist in minimizing these differences (8). However, it was also acknowledged that further interventions are required in order to fully comprehend the optimal methods associated with the reduction of asymmetries; thus, further research is needed in this area.

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Table 1: Mean scores (standard deviation), mean asymmetry percentages, and reliability data for each jump test ($N = 19$)

Test	Mean ± SD	Asymmetry %	CV (%)	ICC (95% CI)
SLCMJ (R)	9.79 ± 2.56	12.54*	2.82	0.99 (0.97-0.99)
SLCMJ (L)	9.29 ± 2.79		3.51	0.99 (0.97-0.99)
SLH (R)	119.21 ± 17.40	6.79	3.94	0.88 (0.76-0.95)
SLH (L)	120.58 ± 14.84		4.18	0.81 (0.64-0.91)
THOP (R)	377.42 ± 52.14	6.81	3.65	0.86 (0.76-0.95)
THOP (L)	378.26 ± 45.04		3.37	0.92 (0.83-0.96)
XHOP (R)	319.58 ± 54.43	5.81	5.42	0.83 (0.67-0.93)
XHOP (L)	326.21 ± 60.43		3.66	0.94 (0.88-0.98)
5m	1.33 ± 0.15	-	3.69	0.91 (0.84-0.99)
10m	2.21 ± 0.22	-	2.72	0.94 (0.89-0.99)
20m	3.85 ± 0.36	-	1.74	0.96 (0.94-0.99)

* denotes significantly higher asymmetry value than all other jump tests ($p < 0.05$)

CV = coefficient of variation, ICC = intraclass correlation coefficient, CI = confidence intervals, SLCMJ = single leg countermovement jump, SLH = single leg hop, THOP = triple hop, XHOP = crossover hop, R = right, L = left, m = metres

Table 2: Correlations between speed tests and jump tests and asymmetry percentages

	SLH (R)	SLH (L)	SLH Asym	THOP (R)	THOP (L)	THOP Asym	XHOP (R)	XHOP (L)	XHOP Asym	SLCMJ (R)	SLCMJ (L)	SLCMJ Asym
5m	-0.30	-0.38	-0.33	-0.22	-0.39	0.35	-0.38	-0.35	0.25	-0.09	-0.27	0.49*
10m	-0.56*	-0.56*	0.12	-0.55*	-0.62**	0.25	-0.61**	-0.66**	0.14	-0.31	-0.49*	0.52*
20m	-0.75**	-0.59**	0.09	-0.70**	-0.59**	0.26	-0.71**	-0.75**	0.37	-0.57*	-0.68**	0.59**

** denotes significant correlation at $p < 0.01$, * denotes significant correlation at $p < 0.05$

SLH = Single leg hop, Asym = Asymmetry, THOP = Triple hop, XHOP = Crossover hop, SLCMJ = Single leg countermovement jump, R = Right, L = Left

Table 3: Correlations between asymmetry percentages and jump test scores

	SLH (R)	SLH (L)	THOP (R)	THOP (L)	XHOP (R)	XHOP (L)	SLCMJ (R)	SLCMJ (L)
SLH %	-0.13	-0.23	-0.18	-0.12	-0.08	-0.12	-0.07	0.01
THOP %	-0.53*	-0.56*	-0.48*	-0.47*	-0.58**	-0.47*	-0.15	-0.33
XHOP %	-0.40	-0.46	-0.29	-0.43	-0.41	-0.45	-0.44	-0.38
SLCMJ %	-0.31	-0.14	-0.39	-0.33	-0.34	-0.45	-0.47*	-0.53*

** denotes significant correlation at $p < 0.01$, * denotes significant correlation at $p < 0.05$

SLH = Single leg hop, THOP = Triple hop, XHOP = Crossover hop, SLCMJ = Single leg countermovement jump, R = Right, L = Left

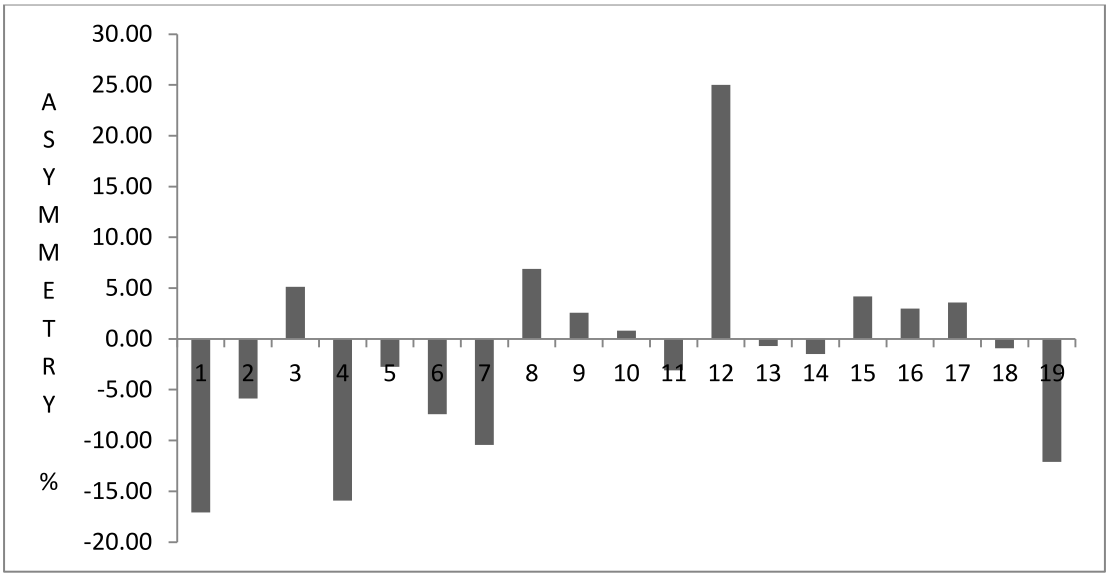

Figure 1: Individual asymmetry percentages for the single leg hop test (negative values are indicative of raw scores being greater on the left limb).

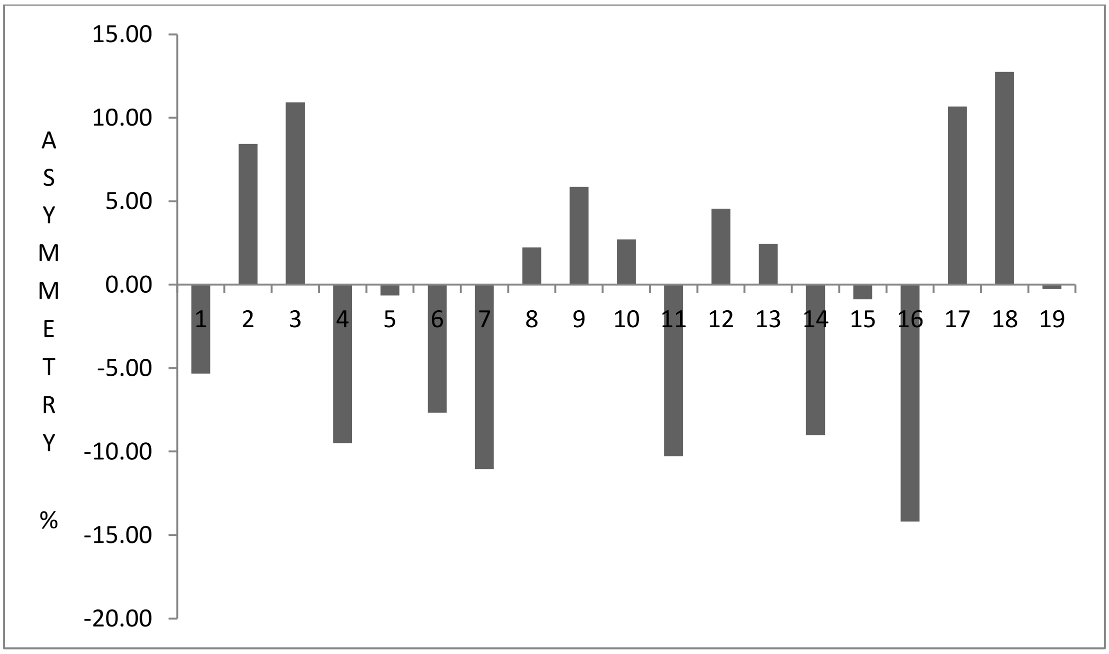

Figure 2: Individual asymmetry percentages for the triple hop test (negative values are indicative of raw scores being greater on the left limb).

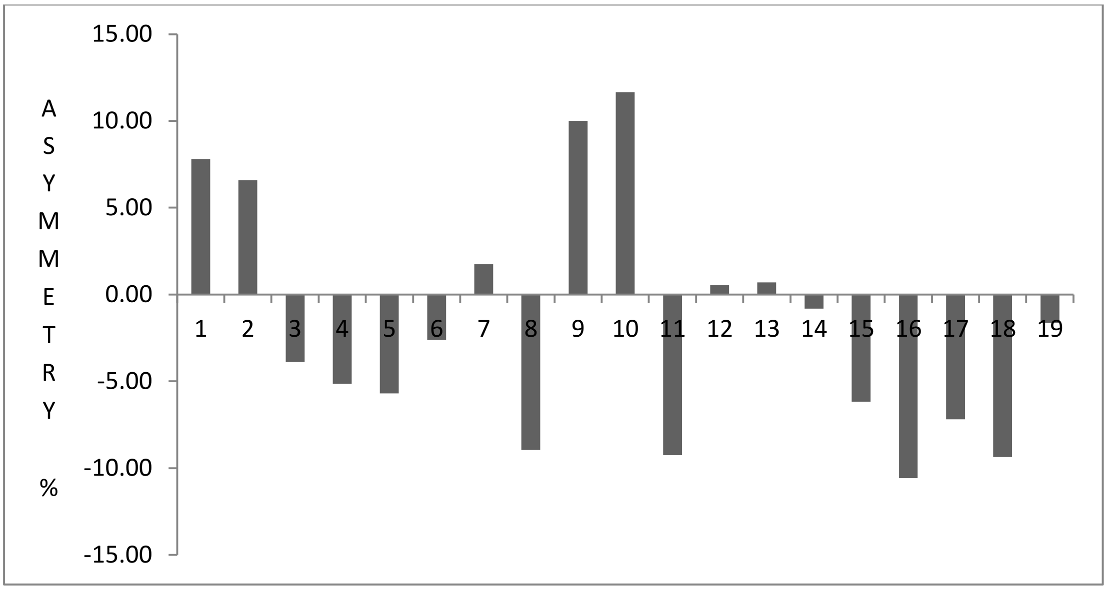

Figure 3: Individual asymmetry percentages for the crossover hop test (negative values are indicative of raw scores being greater on the left limb).

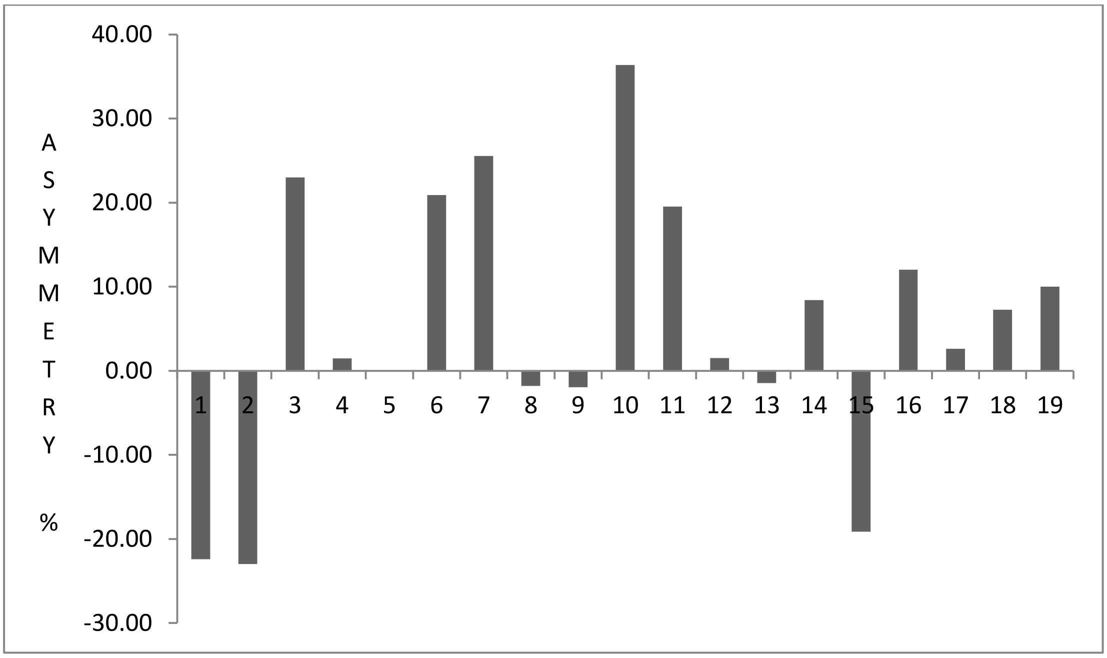

Figure 4: Individual asymmetry percentages for the single leg countermovement jump test (negative values are indicative of raw scores being greater on the left limb).