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Bilateral lower limb asymmetry characteristics of female amateur high school football players

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The measurement of bilateral asymmetry is common practice in many sporting environments and is often measured via left/right comparisons, or differences between dominant and/or preferred limbs. Despite each approach having their merits, these measures are fundamentally different and must be used with caution. This study aimed to identify limb asymmetries contextually relevant to sidedness, preference and dominance and compare the likeliness of asymmetries for jumping and change of direction performance tasks. Nine female high-school footballers volunteered for this study and performed various acyclic and cyclic performance tasks to capture asymmetry characteristics. No significant group differences ($p > 0.05$) were calculated between right and left limbs for the jumping or change of direction tasks. However, participants jumped significantly higher in the vertical jump ($p = 0.017$), and further in the horizontal jump ($p = 0.006$) on their preferred limb compared to non-preferred limb. All jump and change of direction performance tasks were performed significantly ($p < 0.05$) better on the dominant limb compared to the non-dominant limb. Three participants demonstrated imbalances greater than asymmetry thresholds, and a like for like identification of asymmetry had low agreement (56%) when comparing vertical and horizontal jump tasks and poor agreement (22 to 33%) when comparing change of direction to jump tasks. This research extends the importance of testing asymmetry characteristics in sports teams, especially in younger female populations who may be at an increased predisposition of associated injuries. The use of a unilateral acyclic measure of asymmetry is deemed to be the most effective measure of capturing asymmetry in this population and sporting context.

1. Introduction

Bilateral imbalance, or asymmetry, refers to the discrepancies between sides of the body regarding muscular performance or function (Jones & Bampouras, 2010). These imbalances may be influenced by gender, training age, pre-existing injuries, sporting demands and/or anthropometric variables (Cane, Maffulli, & Caine, 2008; Fousekis, Tsepis, & Vagenas, 2010; Hägglund & Waldén, 2016; Hewit, Cronin, & Hume, 2012). Measurement of an individual's asymmetry can aid in identifying prospective injury markers (De Britto, Franco, Pappas, & Carpes, 2015; Xaverova et al., 2015), individual strength imbalances (Hewit et al., 2012), limb dominance (Dos'Santos, Thomas, Jones, & Comfort, 2017) and/or motor skill synchronicity (Vieira et al., 2016).

Bilateral strength imbalances are commonly assessed via comparisons of sidedness (Dos'Santos et al., 2017; Newton et al., 2006), limb preference (Capranica, Cama, Fanton, Tessitore, & Figura, 1992; Samadi, Rajabi, Minoonejad, & Aghaiari, 2009; Valdez, 2003), and/or limb dominance (Daneshjoo, Rahnama, Mokhtar, & Yusof, 2013; Dos'Santos et al., 2017; Dos'Santos, Thomas, Jones, & Comfort, 2018; Sugiyama et al., 2014), through both cyclic and acyclic measures including unilateral jump performance (De Britto et al., 2015; Lockie et al., 2014), isokinetic dynamometry (Daneshjoo et al., 2013; Jones & Bampouras, 2010; Petschnig, Baron, & Albrecht, 1998) and change of direction tasks (Dos'Santos et al., 2017, 2018). These tests utilise a range of metrics including force, time and velocity to measure asymmetry, ultimately comparing percentage difference between limbs. Literature has shown discrepancies

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when comparing sidedness, preference and dominance between limbs (Dos'Santos et al., 2017; Newton et al., 2006); and although each method is commonly used to measure imbalances, these terms are fundamentally different (Sadeghi, Allard, Prince, & Labelle, 2000), and therefore, the need to perform a like for like comparison between methods is required.

Traditionally, an asymmetry index of >10-15% has been considered potentially problematic and highlights an area of concern for an athlete. Various team sports (Hart, Nimphius, Spiteri, & Newton, 2014; Menzel et al., 2013) and rehabilitation literature (Clark, 2001; Petschnig et al., 1998) have adopted this 15% asymmetry index as an indicator of potential injury and rehabilitation protocol success. By doing so, it provides an objective measure of imbalance and guides consequent practise with the hope of keeping players on the field for longer and prevent a premature return to sport. Despite this range being partially accepted by injury and performance literature, this has been refuted in some instances (Bennell, 1998; Beukeboom, Birmingham, Forwell, & Ohrling, 2000). More recently, studies by Dos'Santos et al. (2017) and Lockie at al. (2014), have adopted the use of banded asymmetry thresholds based upon Hopkins (2006) approaches. This strategy acknowledges that asymmetry is commonplace and provides a more sensitive framework than a percentage comparison, which may be conceptually problematic if aiming to discern meaningful change or identify potentially injurious discrepancies.

When investigating sport specific asymmetries such as those observed in footballers, it is important to understand the nature of the motor skills performed in the sport, the movements' performance velocities and the population under investigation. Current research has identified that football is a sport that has an increased risk of lower limb injuries because players often utilise one side over another, potentially creating an environment conducive to generating sport specific imbalances (Cowley, Ford, Myer, Kernozek, & Hewett, 2006; Sannicandro, Rosa, De Pascalis, & Piccinno, 2012). Furthermore, females and those with a lower professional training age are also more likely to display problematic asymmetry characteristics (Bailey, Sato, Burnett, & Stone, 2015; Fousekis et al., 2010; Pappas & Carpes, 2012). This is suggested to be due to factors including inconsistent movement patterns, hip valgus and muscular strength deficits (Bailey et al., 2015; Fousekis et al., 2010). It is suggested that through early identification of asymmetries, corrective training interventions can be administered to facilitate long-term performance and participation. Consequently, it stands to reason that an amateur female football team may be a population that has an increased predisposition to lower limb asymmetries.

This study aims to identify limb asymmetries contextually relevant to sidedness, preference and dominance and compare the nature of asymmetries for jumping and change of direction performance tasks. These tasks mimic the demands of football and may extend to other field-based invasion sports. The purpose of this study is to compare various methods of asymmetry measurement to aid practitioners working with this population in the development of targeted training programmes and coaching strategies aimed at the long-term development and participation of these athletes. Previous literature has informed the hypothesis that significant imbalances will be seen in preferred and dominant limbs, particularly within acyclic jump tasks. Secondly, limb preference and dominance will display greater asymmetries when compared to sidedness within this sporting context.

2. Methods

2.1. Experimental approach

A cross-sectional design was utilised to compare between variables. This testing design was performed to capture and compare the current asymmetry status of the participants in their pre-season condition. All participants wore their own personal active-wear for the singular testing session which was executed on a wooden floor in a school-gym facility. The participants underwent a standardised warm-up and familiarisation process prior to testing commencement. Ethical approval for this study was provided by the Waikato Institute of Technology's Human Ethics Research Group.

2.2. Participants

Nine high school female footballers (mean ± standard deviation; age, 17 ± 1 years; height, 161 ± 1 cm; body mass, 61 ± 12 kg) playing at a 3rd XI level or lower volunteered for this study. All participants provided written informed consent and completed health questionnaires prior to their participation. All were injury free, and not aware of any contraindications that may interfere with data collection.

2.3. Procedures

Height was measured via a free-standing stadiometer (Seca 213; Seca, Hamburg, Germany), with the participant's feet shoulder width apart and participant's head positioned so that their tragus and line of sight were parallel. The headpiece was lowered firmly on the centre of the participant's head whilst standing with erect posture. Weight was taken on electronic scales (Seca 899; Seca, Hamburg, Germany) which were zeroed prior to each participants measurement. The participant's preferred leg was determined via questioning about their habitual kicking preference (Bjelica et al., 2013).

A dual-beam-modulated SWIFT timing light system (Wacol, Queensland, Australia) was used to measure 505 change-of-direction test performance times. Participants were required to sprint from the start line (0m) through the timing lights set at a 10m distance, before turning at the 15m line, and returning through the timing lights as fast as possible (Abdullah et al., 2017). The participants were free to begin each trial after the researcher said the verbal command "when you're ready". Athletes were advised not to overstep the line to avoid adding to their change of direction time (Abdullah et al., 2017).

The single leg horizontal jump (HJ) required participants to perform three maximal unilateral horizontal jumps and land bilaterally. Participants were required to maintain hand placement on the hips throughout the procedure and jump as far as possible in a forwards direction (Hewit et al., 2012). A measuring tape extending from the starting point in the direction of the jump was used to measure the jump to the nearest mm with a ruler placed from the rear-most heel perpendicular to the measuring tape.

Single leg vertical jump (VJ) height was measured via a pre-set Vertec jump system (Power Systems, Knoxville, Tennessee), which required participants to perform a maximal unilateral vertical jump using the ipsilateral hand to swipe the Vertec at the jump apex. Prior to the jump occurring participants were required to stand directly under the Vertec and reach as high as they could while keeping their shoulders square to determine their standing reach height. This value was later subtracted from their recorded jump height (Best et al., 2020). Intersession reliability of the Vertec has previously been reported as ICC: 0.80 for females and ICC: 0.90 for males (Nuzzo et al., 2011).

For each performance test, three trials were performed per leg with approximately two minutes passive recovery between efforts.

2.4. Statistical analysis

The following metrics were calculated for each performance test: Asymmetry index (imbalance between right and left limbs) in the form of a percentage difference was calculated by the following formula (Newton et al., 2006):

% Difference = ((Right limb – Left Limb) ÷ Right Limb) × 100

Limb preference was determined via asking the participants their habitual kicking leg preference (Bjelica et al., 2013). Asymmetry index (imbalance between preferred and non-preferred limbs) was calculated by the following formula:

% Difference = ((Preferred limb – Non-preferred Limb) ÷ Preferred Limb) × 100

Limb dominance was defined as the limb that performed the highest vertical jump, furthest horizontal jump, or fastest CODS performance (Jones & Bampouras, 2010) and calculated as per:

% Difference = ((Dominant limb – Non-dominant Limb) ÷ Dominant Limb) × 100

Descriptive statistics were calculated for all performance tasks and statistical analyses were performed using SPSS (version 24, IBM, Seattle, USA). The assessment of data uniformity (normal distribution) was carried out as per previous literature (Maulder, 2013; Standing & Best, 2019). Specifically, a critical appraisal approach according to the following criteria was utilised. If the difference between the mean and the median was within 10% of the mean, then normality was assumed. However, if the initial criterion was breached, an additional 2 of 4 criteria would also have to be breached for the data to be described as exhibiting non-normal characteristics. These criteria were: (1) mean and standard deviation test (2 × SD > mean); (2) Shapiro-Wilks statistics ($p < 0.05$); (3) skewness and kurtosis statistics (within 1); and (4) skewness or kurtosis ÷ standard error (within 1.96). All performance task data collected in this study were normally distributed thus the following parametric procedures were utilised.

Differences between limbs for all performance tasks were assessed with paired sample t-tests. A p value of < 0.05 was considered significant. Furthermore, effect sizes (Cohen's d) were calculated and interpreted as: 0 – 0.2 *trivial*; 0.2 – 0.6 *small*; 0.6 – 1.2 *moderate*; 1.2 – 2.0 *large*; 2.0 – 4.0 *very large* (Hopkins, Marshall, Batterham, & Hanin, 2009).

Agreement between the dominant limb for performance tasks involved calculating the asymmetry threshold as mean imbalance + (0.2 SD of the mean) for jumps and mean imbalance – (0.2 SD of the mean) for CODS (Lockie et al., 2014). Participants with imbalances exceeding the asymmetry threshold were classified as asymmetrical whereas imbalances below the threshold were classified as balanced (Dos'Santos et al., 2017). The level of agreement between like for like outcomes of asymmetry calculation methods (asymmetrical or balanced) were calculated by the following formula, with percentage agreements ≥80% considered 'good' (Dos'Santos et al., 2017).

% agreement = (frequency of like for like diagnoses ÷ number of participants) × 100

Correction for multiple comparisons has not taken place, due to the small sample size of the present investigation. Application of a correction for multiple comparisons, would likely reduce the corrected alpha level to a level considered too conservative, and thus increase the risk of committing a type 2 error (accepting the null, when it should be rejected), thus given the preliminary nature of this work we present uncorrected values (Havenith et al., 2008; Ouzzahara et al., 2012). We encourage the reader to interpret the p-values presented alongside effect statistics, and consider the percentages alongside their experiences of smallest worthwhile enhancement in applied practice (Datson et al., 2021).

3. Results

No significant differences ($p > 0.05$) were calculated between right and left limbs for the jumping and change of direction performance tasks (see Table 1). Participants were able to jump significantly ($p < 0.05$) higher in the vertical jump, and further in the horizontal on the preferred limb compared to non-preferred limb (see Table 2). All jump and change of direction performance tasks were performed significantly ($p < 0.05$) better on the dominant limb compared to the non-dominant limb (see Table 3). Irrespective of sidedness, preference or dominance, the vertical jump had the largest imbalance (6.8% - 14.3%) or asymmetry threshold (10.5% - 16.4%).

Three participants (3 out of 9; 33.3%) demonstrated like for like dominance in all performance tasks, on the same limb identified as their preferred limb (see Table 4). Participants' limb preference typically matched their vertical jump and horizontal jump dominant limb(s) (6 out of 9; remainder reported even and dominant limb preference).

Figure 1 shows imbalances between right and left limbs for the jumping and change of direction performance tasks. Four, six, and seven total participants demonstrated imbalances greater than asymmetry thresholds of 10.5, 5.3 and -0.5% for vertical jump, horizontal jump, and change of direction speed, respectively. Two participants had sidedness imbalances that exceeded asymmetry thresholds for all performance tasks. A like for like identification of asymmetry had low agreement (56%) when comparing the jump tasks, and poor agreement (22 to 33%) when comparing change of direction to jump tasks (see Table 5).

Table 1: Sidedness comparisons for jumping and change of direction performance tasks.

Metric	Right		Left		Imbalance (%)		*p* value	*Cohen's d*	Asymmetry Threshold (%)
	Mean	SD	Mean	SD	Mean	SD			
Vertical Jump (cm)	27.3	4.8	25.0	4.1	6.8	18.2	0.181	0.52	10.5
Horizontal Jump (cm)	125.6	16.7	120.1	15.4	4.2	5.9	0.055	0.34	5.3
CODS (s)	2.89	0.15	2.89	0.14	-0.1	2.1	0.979	0.00	-0.5

Note: CODS = Change of direction speed.

Table 2: Preference comparisons for jumping and change of direction performance tasks.

Metric	Preferred		Non-Preferred		Imbalance (%)		*p* value	*Cohen's d*	Asymmetry Threshold (%)
	Mean	SD	Mean	SD	Mean	SD			
Vertical Jump (cm)	28.1	4.2	24.3	4.3	12.7	12.6	0.017*	0.88	15.3
Horizontal Jump (cm)	126.4	15.7	119.3	16.1	5.6	4.2	0.006*	0.44	6.5
CODS (s)	2.89	0.14	2.89	0.14	-0.1	2.1	0.937	-0.01	-0.5

Note: CODS = Change of direction speed; * = Significant difference ($p < 0.05$).

Table 3: Dominance comparisons for jumping and change of direction performance tasks.

Metric	Dominant		Non-Dominant		Imbalance (%)		*p* value	Cohen's *d*	Asymmetry Threshold (%)
	Mean	SD	Mean	SD	Mean	SD			
Vertical Jump (cm)	28.3	4.2	24.1	4.0	14.3	10.5	0.004*	1.01	16.4
Horizontal Jump (cm)	126.4	15.7	119.3	16.1	5.6	4.2	0.006*	0.44	6.5
CODS (s)	2.87	0.15	2.92	0.13	-1.7	1.3	0.004*	-0.34	-1.9

Note: CODS = Change of direction speed; ES = effect size; * = Significant difference ($p < 0.05$).

Table 4: Matches between preferred limb and dominant limb during jumping and change of direction performance tasks.

Participant	Preferred Limb	VJ Dominant Limb	HJ Dominant Limb	CODS Dominant Limb
1	R	R	R	R
2	L	L	L	L
3	R	R	R	R
4	R	L	E	R
5	R	R	R	L
6	R	R	E	L
7	R	E	R	R
8	R	R	R	L
9	R	R	R	L
Preference Match (#, %)		7, 78	7, 78	5, 56

Note: VJ = Vertical jump; HJ = Horizontal jump; CODS = Change of direction speed; R = Right; L = Left; E = Equal.

Table 5: Percentage agreements between like for like identifications of asymmetry classification.

		Vertical Jump	Horizontal Jump	CODS
Frequency (#)	**B**	5	3	2
	L	1	1	4
	R	3	5	3
% agreement with VJ performance like for like identification (#, %)			5, 56	2, 22
% agreement with HJ performance like for like identification (#, %)		5, 56		3, 33
% agreement with CODS performance like for like identification (#, %)		2, 22	3, 33	

Note: CODS = Change of direction speed; B = Balanced; L = Left Asymmetrical; R = Right Asymmetrical.

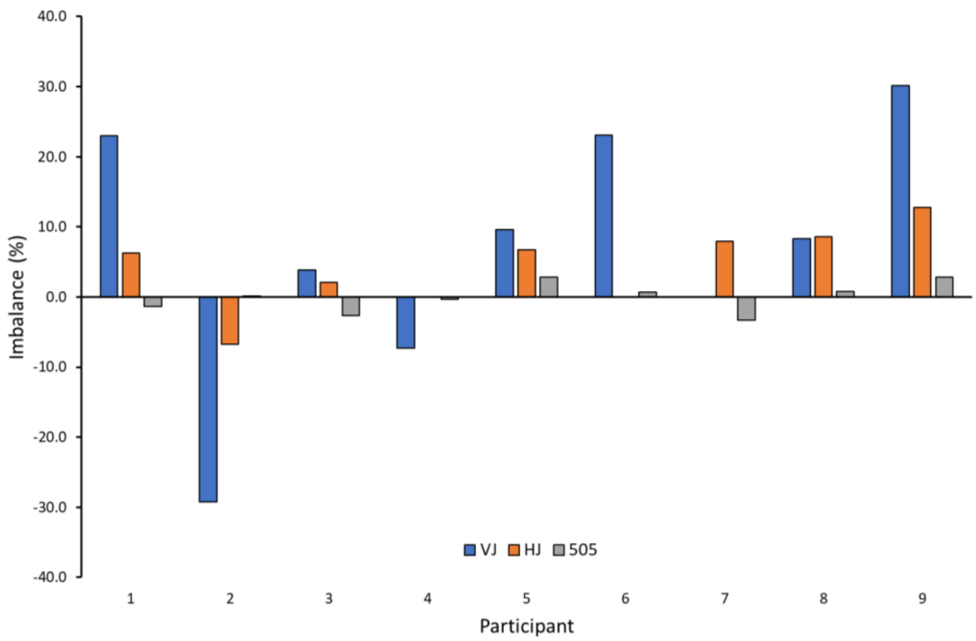

Figure 1: Left and right imbalances for vertical jump, horizontal jump and 505 performance tasks.

4. Discussion

This study aimed to identify limb asymmetries of amateur female footballers contextually relevant to sidedness, preference and dominance and compare the likeliness of asymmetries for jumping and change of direction performance tasks. Levels of asymmetry were considered potentially problematic in the vertical (n = 4) and horizontal jump (n = 4) and COD (n = 4) tasks for this cohort. Preferred vs non-preferred imbalances were significant ($p < 0.05$) in jump tests (Table 2), with dominant vs non-dominant statistics displaying significant asymmetries in both jump and COD tasks (Table 3), therefore supporting the hypotheses. Interestingly, 78% of jump tasks displayed a performance match between preferred and dominant limbs, whilst COD tasks presented with a 56% match, suggesting preference and dominance may vary in description and application between various movement tasks. Finally, there was poor agreement when comparing like for like asymmetries between jump and COD tasks (VJ = 22%, HJ = 33%), which highlights that asymmetries in acyclic jump tasks may not correspond with asymmetries in cyclic COD tasks.

The development of asymmetry is often attributed to the repetitive and at times asymmetric nature of sporting movements (Hadzic, Sattler, Markovic, Veselko, & Dervisevic, 2010). In the present cohort, there are several individuals displaying potentially problematic asymmetry measures (Table 5), with dominance values exceeding the established asymmetry thresholds for VJ (n = 4), HJ (n = 4) and COD (n = 4). It is important to note, that only one individual presented as problematically asymmetric for all tests. Based on these findings and support from previous literature, these individuals may have a greater likelihood of strength, stability and skill performance imbalances (Sadeghi et al., 2000), possibly fostering an increased likelihood of asymmetry-related lower limb injuries (Brophy, Silvers, Gonzales, & Mandelbaum, 2010; De Britto et al., 2015). This is not unreasonable due to the elevated injury statistics associated with football players (Bjelica et al., 2013; Sannicandro et al., 2012) and female non-contact ACL injuries (Cowley et al., 2006). It is recommended that trainers, coaches and athletes attempt to re-align the imbalance through strength and movement tasks requiring both multi-limb coordination and segment sequencing (Fousekis et al., 2010; Hewit et al., 2012; Lockie et al., 2014; Wright & Laas, 2019). These training elements will help to decrease the imbalance and in turn decrease the potential for future injuries and performance decrements – a worked example of this in a return to play programme following recurrent knee injuries can be found in Wright and Weston (2014).

As advised by Schlumberger et al. (2006) and Jones and Bampouras (2010), strength differences in the lower limb cannot truly be estimated in group settings by left-right comparisons or limb preference. The results of the current study support this statement, and have highlighted that by establishing multiple measures of asymmetry via limb dominance specific to the individual test, clearer imbalances may be identified in a comparative strength context, as per the findings of Dos'Santos et al. (2017). Furthermore, some of the observed asymmetry may be accounted for by intra-individual variability in performance and variability within the test. For example, we have previously established the importance of providing proper familiarisation for vertical jump performance (Best et al., 2020), despite being shown to possess acceptable levels of reliability (Nuzzo et al., 2011). Likewise, horizontal jump performance (Standing et al., 2019) and change of direction performance (Wright & Atkinson, 2019) may improve as a result of maturation, thus if one were to perform these tests as part of an annual or repeated testing battery, biological maturity also warrants consideration, especially if used to inform strength and conditioning approaches (e.g., Wright & Laas, 2019) or when used as part of a larger testing battery due to potential collinearity due to neurological transfer (Wright et al., 2014).

Comparisons of left and right limb performances showed no significant differences ($p < 0.05$) at the group level (Table 1). Similar to the results seen by Jones and Bampouras (2010), this finding suggests that left and right comparisons are limited in application when looking at strength-based performance measures. This statement is further supported by Schlumberger et al. (2006), who suggests the need to evaluate strong-weak-leg-differences rather than sidedness, as the assumption that these two measures are the same lacks adequate validity. This is likely due to the multitude of individual factors that influence performance such as limb preference, previous injury, sport-specific demands, movement tasks and training experience (Jones & Bampouras, 2010; Sadeghi et al., 2000; Schlumberger et al., 2006). It is therefore noted as un-wise to use left and right comparisons for athletes without first identifying individual performance characteristics and demands of the movement task.

Conversely, when comparing preferred and non-preferred kicking limb (Table 2), significant differences in performance were identified for jump tasks only (VJ $p = 0.017$, HJ $p = 0.006$). This suggests that individual limb preference identifies clearer asymmetry characteristics than sidedness comparisons and may be used to differentiate performance for jump tasks, but not for COD tasks. It is important to note that limb preference does not necessarily match the dominant limb within this population, especially in the 505 tasks. Using the 505 total completion time as an indirect measure of bilateral asymmetry means the non-tested limb is utilised in the acceleration and linear speed components of the test. Dos'Santos et al. (2018), states this involvement may in fact hide the imbalance and dilute the input of the tested limb during this particular style of test. This theory has been further supported by literature (Nimphius, Callaghan, Bezodis, & Lockie, 2018), where it was found that athletes changed their technique in the 505 test to load the preferred leg when changing direction on the non-preferred leg; therefore concluding that this test has limited practical utility in some populations (Taylor et al., 2019).

The above supports the notion that change of direction tasks are multifactorial and include elements of foot placement, adjustment of strides, posture, body lean, and several other acceleration/deceleration variables (Dos'Santos et al., 2017; Sheppard & Young, 2006; Young, James, & Montgomery, 2002). It is recommended that acyclic tasks be utilised where possible to test for asymmetries to clearly define the roles of each limb, remove multifactorial variables associated with cyclic tasks and therefore improve the validity of the tests utilised. This interpretation clearly supports Schlumberger et al. (2006) and Jones and Bampouras (2010), who also state that strength differences in the lower limb cannot truly be estimated by left-right comparisons or limb preference.

Limb preference matched limb dominance in 78% of both jumps tasks, but only 56% of COD performances. In alignment with Dos'Santos et al. (2017) agreement levels >80% were considered 'good'. Table 4 begins to highlight a potential justification for this finding; the dominant limb for COD and jump tasks varies for all but three participants. This may be attributed to the cyclic nature of the COD test, which requires input from both limbs in a repetitive and non-specific manner. It is also suggested that the jump and COD tasks required varying force application characteristics across multiple planes (Dos'Santos et al., 2017). Previous literature that has utilised the dominant vs non-dominant approach of measuring asymmetry have identified significant differences in single leg vertical jumps (Meylan, Nosaka, Green, & Cronin, 2010; Miyaguchi & Demura, 2010), drop jumps (Schiltz et al., 2009), and COD tasks (Dos'Santos et al., 2017; Hart et al., 2014), supporting the findings of the current study. It was identified that limb dominance displayed significant differences between vertical (p = 0.004), horizontal jump (p = 0.006) and COD (p = 0.004). Interestingly, the term 'dominant limb' has been described as being the limb responsible for mobilisation (Sadeghi et al., 2000), preferred leg for kicking a ball (Fagenbaum & Darling, 2003), strongest limb (Jones & Bampouras, 2010) and/or a combination of these terms (Maulder, 2013) in previous literature. This study adopted the strategy of 'best vs worst' in alignment with other research (Dos'Santos et al., 2018; Jones & Bampouras, 2010; Petschnig et al., 1998), in order to measure a raw performance difference, replicable of those witnessed during competitive and real-world environments in a worst case scenario. The findings of this method of asymmetry characterisation suggest that dominance-based comparisons of force and velocity through unilateral jump and COD tasks are the best strategy to highlight both strength and potential performance imbalances within this population.

4.1. Practical applications

This research extends the importance of testing asymmetry characteristics in both team and individual sports, especially in younger female populations who may be at an increased predisposition of associated injuries. Sidedness and limb preference have been shown to be less effective at highlighting performance asymmetries when compared with limb dominance. The use of unilateral acyclic testing of asymmetry is further recommended over cyclic tasks that require input from both limbs, as this may hide the imbalances in the recorded performance measure. Coaches, trainers and strength and conditioning practitioners should adopt a thorough multi-test approach to identifying asymmetry and aim to minimise asymmetries that exceed the 15% threshold, if deemed non-functionally relevant. This may be achieved through incorporating purposeful and sport specific movements to ensure the longevity of athletes and help reduce the likelihood of asymmetry-related injuries. As limb preference does not necessarily match the dominant limb within this population, especially in the 505 tasks; it is recommended that testing and monitoring practices should be implemented to capture this information, rather than reliance on individual feedback.

Conflict of Interest

The authors declare no conflict of interests.

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