Measuring inter-limb asymmetry for strength and power: A brief review of assessment methods, data analysis, current evidence, and practical recommendations.

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Abstract

The aim of this brief narrative review is to summarize the present evidence, provide recommendations for data analysis, and appropriate training methods to reduce strength and power asymmetries within athlete populations. Present evidence shows that a strong interest in the assessment of asymmetry exists. Despite the perceived associated relationship between asymmetry and injury and performance, a clear link is still missing. Practitioners need to be aware of this when they decide to assess asymmetries and later design training interventions. Several bilateral and unilateral tests could be used to assess asymmetries such as isokinetic dynamometry, the isometric mid-thigh pull, squat and Nordic hamstring exercise. Based on the current evidence, future investigations require further standardization of methodology and analysis to optimize interpretation (e.g., within session and between session), adoption, and implementation of inter-limb asymmetry testing and appropriate interventions. In this review three training interventions have been proposed to reduce existing lower limb asymmetries in sport populations: traditional resistance training, flywheel resistance training, and combined training interventions, with some evidence suggesting such interventions can reduce lower limb asymmetries. Nonetheless, the number and quality of articles currently available are too limited to draw firm conclusions, therefore, further research is needed to verify whether training interventions can achieve these aims. To develop an understanding and application of interventions addressing inter-limb asymmetries within the sport, greater methodological rigor should be applied towards study design, data analysis and interpretation of future investigations as well as when appraising the current literature.

Keywords: resistance training, performance, jump, flywheel, injury, sport.

INTRODUCTION

Understanding the complex nature of sport-specific tasks and quantifying the physical capacities that underpin them are of significant interest to the sports science community (6,12). Specifically, analysis of inter-limb asymmetries on injury burden, it's use in return to sport, and relationship with sport performance has received much attention (13,22,35,44). Investigating inter-limb asymmetries consists of comparisons between dominant and non-dominant, stronger and weaker, or injured and non-injured limbs (6,12). Assessment of physical capacity (*i.e.*, strength, jumping, power, balance, range of motion, etc.) is frequently performed and ranges widely in sport (22). The assessment of asymmetries has grown from singular time point "snap shots" to a more dynamic process (i.e., longitudinal monitoring) that accounts for direction of asymmetry and differences between bilateral and unilateral deficits (9,15). Nonetheless, little can be done with asymmetry data if analysis and interpretation is inappropriate (28). The question: "Practically, what should be done with a, e.g., 5, 14, or 19% inter-limb asymmetry?" remains a difficult one to answer. Appraisal of the present evidence is limited by the varied definitions of asymmetry and its associated importance towards both injury and performance (13,35). Indeed, many questions remain about how such values should be interpreted to stand a chance of bringing about actionable change. Regarding tests employed, several jump and strength tests have been devised for the evaluation of inter-limb asymmetry and are often used as key criterion markers alongside performance parameters with athletes that are either healthy or returning to sport after injury (22,51). Given the importance of lower limb strength and power for athletic populations (8), the assessment of asymmetry for these physical capacities seems especially relevant and valid.

The use of jump testing in elite sport has proliferated because it provides easily accessible, cheap and valuable inter-limb asymmetry data (51). Such information is often considered when aiming to reduce likelihood of injury or re-injury during rehabilitation with athletes (12,53). In fact, unilateral jump tests (*i.e.*, repeated unilateral hopping) have been validated to quantify inter-limb differences that are often key during the rehabilitation process but are also relevant to independent markers of sport performance (33,44). Specifically, larger unilateral countermovement jump (CMJ) asymmetries have previously been associated with worse acceleration and sprint performance in youth female and youth male team-sport athletes (18,30). In addition, greater asymmetry during unilateral drop jumps have also been related to inferior change of direction (COD) and sprint performance in adult female soccer players (21). Nonetheless, within the same investigation, no association between larger unilateral CMJ asymmetry and worse COD and sprint performance existed (21). Similarly, higher levels of unilateral vertical jump asymmetry in professional female soccer players did not impair speed nor power performance (42). Where adult males are concerned, small inter-limb asymmetries in distance hopped appear to have no association with reduced COD or multi-directional speed performance (41). In agreement with the aforementioned findings, no consistent associations between jump asymmetries and COD or sprint performance of elite youth (U18 and U23s) soccer players were found over the duration of a soccer season (14). Thus, it seems apparent that the link between jump asymmetries and sport-specific skills or performance is not consistently evidenced and needs to be further investigated (22).

Assessment of inter-limb strength asymmetries are particularly important because they can potentially help identify athletes at risk of adopting dysfunctional or ineffective movement patterns that negatively impact performance (12,22). Inter-limb strength asymmetry testing can be performed with a variety of equipment ranging from isokinetic dynamometers to assessments of exercises (*i.e.*, back squat) with force-plates (12). A relationship between larger lower limb peak force asymmetries and reduced overall strength (13) as well as impaired sport specific kicking ability has been previously reported (32). Interestingly, some evidence suggests that sub-elite and youth athletes present larger inter-limb strength asymmetries than elite athlete populations (12,59). Although youth athletes have shown to present greater asymmetries, the literature also suggests that such asymmetries are not guaranteed to negatively impact athletic performance (54). The variation in the present literature may be related to the fact that sporting tasks are underpinned by multiple physical qualities and involve high levels of skill rather than solely rely on strength, power, and inter-limb asymmetries. Finally, it is important to consider that due to the associative designs of the aforementioned studies, it is not possible to infer a cause-and-effect relationship. In fact, future investigations should prioritize whether training interventions may induce specific changes in asymmetry and establish whether reducing such asymmetry meaningfully directly improves performance of sporting tasks.

Although the need for investigation into the link between asymmetries and sport performance is clearly needed, a great deal of consideration must be made for the methodology, analysis, and interpretation of inter-limb asymmetries to validate the findings of future investigations. In fact, the present literature lacks clarity on the optimal way to assess, analyze, and reduce (strength and power) inter-limb asymmetries with athletes. Therefore, the aim of this brief narrative review is to summarize the present evidence, provide recommendations for data analysis, and appropriate training methods to reduce strength and power asymmetries within athlete populations.

ASSESSMENT OF ASYMMETRIES AND DATA ANALYSIS

Assessing inter-limb asymmetry

Assessment of physical capacities and asymmetries should be dictated by the needs analysis of the sport and athlete in question (13,22,35,44). Once they are determined, if it is deemed that assessing and monitoring asymmetry holds additional value for the practitioner, then it can be integrated into the routine monitoring process. Whilst almost any physical quality can be assessed for asymmetry (provided separate dominant and non-dominant limb data can be obtained), much of the literature appears to have focused on strength and jumping tasks, and as such, this section will focus on these physical capacities (6,11,12,15,24).

Asymmetry in strength tasks. Numerous methods have been used to assess lower limb inter-limb asymmetry in strength such as isokinetic dynamometry (12,24,56), isometric mid-thigh pull and squat (13,27,32), or even compound movements such as the back squat itself (57) and Nordic hamstring exercise (NHE) (23). Isokinetic dynamometry of the lower limbs can provide a detailed profile of asymmetry, given between-limb data can be obtained for both the quadriceps and hamstrings at varying speeds of movement (6). This notion of varying contraction speeds is useful if practitioners want to bias an assessment towards either force or velocity. Furthermore, previous research has shown excellent reliability for the assessment of peak torque, when assessing flexion and extension both concentrically and eccentrically at 60°/s (ICC = 0.93-0.95), 180°/s (ICC = 0.93-0.96), 240°/s (ICC = 0.93-0.95) and 300°/s (ICC = 0.82-0.97) (2,37,58). However, the use of this equipment is largely confined to a laboratory, making this unfeasible for many practitioners. Instead, asymmetry data can be obtained from iso-weight devices (e.g., back squat and leg-press using free-weights or stack machines), which are commonly used in strength and conditioning programs (13,22). The use of these devices enables data to be collected during training sessions, which would increase the external validity of such assessments; furthermore, iso-weight testing methods have reported excellent reliability scores (generally, ICC > 0.90) (31,47). Another method to assess asymmetries requires the utilization of twin force plates, which are needed to gather separate data for each limb. In this case, the isometric mid-thigh pull and squat can be performed and offer information about lower limbs asymmetries (13,27,32). Although this approach is valid, it may not always be practical or possible for some practitioners who do not have such technology. In contrast, only a single force platform is needed if a unilateral assessment method is chosen (e.g., unilateral isometric mid-thigh pull or squat), which provides an understanding of maximal force production capabilities. Further to this, previous research using these methods have shown that larger asymmetries in peak force are associated with reduced overall strength levels (13) and accuracy in kicking (32). However, whilst a variety of metrics can be obtained from these two assessments (e.g., peak force, impulse and rate of force development at different time intervals), the only consistent and reliable metric appears to be peak force, when assessing unilaterally (ICC = 0.93-0.97; CV = 4.15-5.70%) (17).

Practitioners may choose to assess eccentric strength in athletes for several reasons, but mainly, for improving performance and reducing the likelihood of injury (4,46). One common method is to assess asymmetries during the NHE, however, the current information is somewhat limited. Cuthbert et al. (25) compared the NHE to three other isometric hamstring strength assessments and found that the NHE showed the best between-session reliability (coefficient of variation (CV = 2.89-4.01%) compared to other methods (CV = 6.27-10.23%). In addition, the Kappa coefficient statistic, which is used to highlight consistency in the "direction of asymmetry" between test sessions, reported that the NHE demonstrated *substantial* levels of agreement (K = 0.62) compared to *slight* to *moderate* levels of agreement for the other methods (K = 0.03-0.47) (25). The current evidence, although studies on strength asymmetry are limited, suggests that the unilateral isometric mid-thigh pull or squat tests, and the NHE can be used as valid tests to assess lower limb strength asymmetries.

Asymmetry in jumping and lower limb power tasks. Similar to strength, a wide variety of jumping tasks can assess inter-limb asymmetries. For example, countermovement jumps (CMJ) (7,34), drop jumps (45) and a variety of horizontal hopping (continuous unilateral jumping) tasks (13,16) have all been previously employed, each of which has shown acceptable reliability data both bilaterally and unilaterally (ICC = 0.68-0.99; CV = 2.82-9.18) in a number of studies (9,13,14,16). Since inherent differences between jumping tasks (stretch-shortening cycle function and plane of movement) exist, not all jump tests (and asymmetry analysis) are suitable for practitioners, who ultimately, should select the most appropriate test based on the sport of their athletes. Apart from consideration for the needs of the sport, two key points should be considered when selecting jump tests for the detection of inter-limb differences. The first relates to whether the test is unilateral or bilateral in nature, while the second point is related to the specific characteristics of the task.

1) Bilateral vs. unilateral jumping. Although both could be relevant for practitioners, these tests offer different information. For example, bilateral jumps (since two limbs are involved in the task) allow for greater (total) power outputs, jump height, concentric and eccentric velocity than unilateral jumps. Logically, bilateral jumps could be preferentially used in sports where such bilateral movements are more common (*e.g.*, volleyball). While unilateral tasks may not allow for force and power compensation between the limbs during the task (since only one limb is used at time), unilateral jumps may be a better measure of "actual limb capacity" and therefore, potentially more sensitive at detecting asymmetries (20). To support the notion that differences exist between these two tests, previous research has shown that the direction of asymmetry revealed *poor* levels of agreement (all Kappa values < 0) between bilateral and unilateral CMJ for mean force, concentric and eccentric impulse (11). Furthermore, key differences between such tests have been recently reported showing that bilateral and unilateral CMJs present different limb dominance characteristics and practitioners should avoid using one test to represent the other (10). An asymmetry measured during a bilateral task may be masked by some athlete's compensation strategies, whilst an asymmetry measured unilaterally may be considered more of an imbalance in jumping capacity.

2) Asymmetry is highly task and metric-specific in nature. An abundance of literature reports that asymmetries between tasks are unlikely to be matched (11,22,38,48,60). Simply put, if an asymmetry of 5% or 10% is achieved in a given test, it should not be assumed that the same or similar values would be achieved in another test. Additionally, although group mean data rarely changes significantly between test sessions, analysis of individual data shows that asymmetries can vary considerably between sessions (15,25). Thus, individual, rather than group analysis, has been recommended for asymmetry assessments (13). Additionally, asymmetry is almost always computed and presented as a percentage value. However, it is not always apparent as to what this value represents, often requiring further explanation for practitioners.

Data analysis for inter-limb asymmetry

Regardless of testing outcome, use of asymmetry data may differ slightly within a single session in comparison to multiple sessions. This section will provide the practitioner with some suggestions on how to meaningfully interpret an individual's inter-limb asymmetry data in both scenarios.

Within-session analysis. Asymmetry should only be considered "real" if the between-limb percentage value is greater than the intra-limb variability assessed with a CV (28) – a concept that has been employed recently (13,19). If an athlete exhibits a real asymmetry, it may not require an immediate intervention to correct the imbalance. However, awareness of persistent real asymmetries (i.e., repeated test sessions over time) may highlight potential limb capacity issues that may need to be addressed (44).

Between-session analysis. During test-retest designs or longitudinal analyses, comparing changes in asymmetry to the baseline CV values would confirm whether changes in the signal (asymmetry) are greater than the noise (baseline CV). When assessing percentage change, the difference (between time points) is typically computed relative to where it came from (i.e., baseline) (13,19). A second point of consideration relates to the direction of asymmetry: it is important to remember that asymmetry is a ratio, making it comprised of two individual parts (i.e., dominant and non-dominant limb scores). Thus, when practitioners treat asymmetry as a single number, no context is provided for which limb performed superiorly. The Kappa coefficient statistic enables analysis of the levels of agreement for the direction of asymmetry (i.e., limb dominance) between test sessions (25). This concept can be simply explained with the following example: if an athlete jumps higher on their dominant leg initially, the next testing session will aim to establish (regardless of the magnitude of asymmetry) whether the dominant limb is still outperforming the non-dominant side. Intuitively, practitioners may not think any obvious reason exists as to why this should fluctuate between test sessions, especially if no training intervention has been conducted. However, recent evidence has shown that levels of agreement are far from perfect between test sessions (15,25), indicating that: 1) fluctuations in limb dominance may be a naturally occurring phenomenon and, 2) the reliability of asymmetry of some tests may be low, therefore, practitioners should verify the reliability of their tests before incorporating them in to their routine monitoring process. Although clear guidelines on the treatment of asymmetries are currently unavailable, it is the authors' opinion that athletes who exhibit consistent limb dominance patterns over time may need specific targeted training interventions while athletes that show these natural fluctuations between limbs may not need any specific intervention.

The link to a YouTube video of how to compute the Kappa coefficient in Microsoft Excel is reported in the supplementary material.

RESISTANCE TRAINING METHODS FOR REDUCING ASYMMETRIES

Traditional resistance training methods

A recent meta-analysis by Bettariga et al. (8) investigated the effects of training interventions on inter-limb asymmetries, measured across a range of physical performance tests. In summary, the asymmetry tests most commonly used to demonstrate changes in side-to-side differences are a range of unilateral jump and change of direction (COD) speed tests. When training methods are considered, the majority of traditional resistance programs have utilized a combination of strength and jumping based exercises over a period of 6-10 weeks.

For example, Bazyler et al. (26) used 20 recreational strength trained males to perform a bilateral back squat training intervention, consisting of 6 sets of 3-5 repetitions ranging from 85-92% of 1 repetition maximum (1RM), twice a week for 7 weeks, with the second session having a 10-15% drop-off in intensity each week. Isometric peak force asymmetry was measured at 90 and 120° knee angles on twin force plates, with the group sub-divided into strong ($n = 10$; 1RM back squat = 168 kg) and weak ($n = 10$; 1RM back squat = 138 kg) groups, pre-intervention. The strong group started the intervention almost perfectly symmetrical ($\leq$ 2.2%) and thus, showed no meaningful change in asymmetry post intervention. However, the weak group showed significant reductions in asymmetry at both 90° ($P = 0.045$; 3.9 → 1.9%) and 120° ($P = 0.007$; 4.6 → 3.9%) conditions (26). Intuitively, practitioners may think that unilateral-based exercises should be prioritized to reduce lower limb asymmetries; however, it seems that consistent training using the back squat may also be a possible means of minimizing existing side-to-side differences. Pardos-Mainer et al., (2020) investigated the effects of two weekly strength and power training sessions over an 8 week period in female soccer players (49). In this study, a short-term in-season combined strength and power training program induced greater speed and COD performance improvements than soccer training alone in adolescent female soccer players, however, no variations in interlimb-asymmetry tests were reported ($P > 0.05$; effect size [ES]: -0.13 to 0.57). Although this study reported improvement in sport performance, it was not suitable to reduce inter limb-asymmetry, which highlights that more research is needed to verify the validity of strength and power training programs to reduce any existing imbalances. Currently, we do not have strong evidence in support of traditional training interventions, which should be considered in future study designs.

Flywheel resistance training methods

Although flywheel training has been investigated with a variety of populations relating to strength, power, and athletic performance (1,5,52,55) – less is known about its efficacy in reducing inter-limb asymmetries (8,40). Flywheel training exercises ranging from (bilateral, unilateral, lateral) squats to multi-directional movements have been applied with the objective of reducing inter-limb asymmetries (29,39,43). Madruga-Parera et al. (35) reported that sixteen sessions of multi-directional flywheel training over 8 weeks enhanced sport-specific performance (*i.e.*, change of direction [COD] and jump) but did not reduce asymmetry. Meanwhile, weekly lateral squat training sessions over 10 weeks improved jump height asymmetry and CMJ performance (29). However, the present literature is limited to youth male athletes and may not appropriately represent the effects of flywheel training on inter-limb asymmetries in elite athletes or female populations (40). Additionally, the training implemented may not have been ideal for achieving eccentric overload (43), which is an important feature of flywheel training (3). In particular, the ability to produce demanding eccentric phases may be particularly important for developing strength, optimizing performance, and potentially reducing inter-limb asymmetries (3,8,40). Although multi-directional and lateral flywheel exercises both improved sport performance parameters, their impact on inter-limb asymmetry is not as clear. In agreement with the aforementioned inconclusive results, no clear relationships exist between asymmetry parameters (COD, flywheel lateral squat power, or jump) and sport performance measures (sprint or jump) in youth soccer players (54). The current flywheel literature highlights an unclear link between the performance of athletic tasks and inter-limb asymmetry during flywheel training in sporting populations.

Combined training interventions

Dello Iacono et al. (2016) investigated the effects of core stability training on unilateral CMJ height asymmetry in 20 adolescent soccer players (36). For the intervention group, CMJ height asymmetry was reduced from 5.4 to 1.6% ($P = 0.001$; ES = 2.01), whilst the imbalance in the control group increased from 4.8 to 7.2% (ES = 1.28). Intuitively, whilst this reduction in asymmetry may seem favorable, a closer inspection of the training program shows that whilst some core-based exercises were programmed (e.g., seated torso rotation and kneeling superman's), so too was some more fundamental strength exercises (e.g., the NHE and walking lunges), in addition to maximal effort 5-m accelerations. Therefore, it seems likely that reductions in jump height asymmetry could be attributable to strengthening the lower body, rather than exclusively to core-based exercises.

Another research group used the FIFA 11+ program twice a week for 10 weeks with female soccer players aiming to improve physical performance and reduce inter-limb asymmetries (50) . This study reported changes in unilateral broad jump asymmetry distance, unilateral CMJ height, and COD time during two different tests but no meaningful changes in asymmetry were evident for any test ($P > 0.05$). Although it is of significant interest, the current evidence supporting the use of training methodologies to reduce strength and power asymmetries with athletic populations is limited and unclear. Currently, the most appropriate strategy to manage strength and power asymmetries with athletes appears to be consistent application of resistance training methods to improve strength and subsequently reduce underlying imbalances.

*****Table 1 near here, please*****

LIMITATIONS AND FUTURE DIRECTIONS

This review is not without limitations, the first limitation is related to the link between some asymmetry tests (e.g., jumps) and sport-specific skills or performance, which is not consistently evidenced and needs to be further investigated (22). Future investigations should aim to determine whether improving imbalances between limbs actually enhances key performance parameters or reduces likelihood of injury concurrently. A second limitation is related to the inconsistency that is frequently found between asymmetry scores using different tests. For example, an asymmetry could be detected using one lower limb test but may not be detected using another assessment. This type of inconsistency in the evaluation of lower limb asymmetries could be explained by the very nature that asymmetry scores are test specific and should not be, therefore, inferred from other tests. Finally, and relating to previous suggestions regarding data analysis for asymmetry: an individual approach that considers the magnitude of asymmetry relative to the CV; and consistency in the direction of asymmetry is likely needed on a case-by-case basis, to better understand the relevance of any existing inter-limb differences. However, further research is needed to verify the general reliability of asymmetry tests (e.g., ICC and CV) as well as the consistency of tests to evaluate the direction of lower limb asymmetries.

CONCLUSIONS

The aim of this brief narrative review was to summarize current assessment methods, data analysis, and exercise interventions for reducing lower limb strength and power asymmetries with athletic populations. It is clear from the existing evidence that a strong interest in the assessment of asymmetry exists because of the associated importance relative to both injury and performance. Despite this, a clear link is missing, therefore practitioners need to be aware of this when they decide to assess asymmetries and later design training interventions that may in part, be influenced by such asymmetries. Currently, several bilateral and unilateral tests that could be used to assess asymmetries such as isokinetic dynamometry, the isometric mid-thigh pull, squat and NHE. Based on the current evidence, future investigations require further standardization of methodology and analysis to optimize interpretation (e.g., within session and between session), adoption, and implementation of inter-limb asymmetry testing and appropriate interventions. Regarding the use of intervention protocols to reduce existing lower limb asymmetries in sport populations, based off the limited evidence to date, it seems logical to suggest that consistent strength training over time, may be a valid method for reducing any existing inter-limb asymmetries. Furthermore, given the accepted importance of strength training for both improving athletic performance and reducing non-contact injuries, this seems like a sensible suggestion for practitioners to keep in mind. In this review three training interventions have been proposed: traditional resistance training, flywheel resistance training and combined training interventions, with some evidence suggesting such interventions can reduce lower limb asymmetries. Nonetheless, the number and quality of articles currently available are too limited to draw firm conclusions. Therefore, further research is needed to verify whether training interventions can achieve these aims. To develop an understanding and application of interventions addressing inter-limb asymmetries within the sport, greater methodological rigor should be applied towards study design, data analysis and interpretation of future investigations as well as when appraising the current literature.

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Supplementary material

The Kappa coefficient has been introduced in this paper, therefore a YouTube video of how to compute the coefficient in Microsoft Excel has been previously recorded and it can be viewed at this link: https://www.youtube.com/watch?v=PVOoBb4rNMk&t=2s

Table 1. Summary of the assessment methods, data analysis, current evidence, and future directions of inter-limb asymmetry for strength and power.

Assessment	**Data analysis**	**Evidence**	**Future directions**
Several tests can be used to assess asymmetries such as isokinetic dynamometry, isometric mid-thigh pull and squat, or even compound movements such as the back squat itself and NHE	Within-session analysis: If an athlete exhibits a real asymmetry, it may not require an immediate intervention to correct it. However, awareness of persistent real asymmetries may highlight potential limb capacity issues that may need to be addressed	It is clear from the existing evidence base that a strong interest in the assessment of asymmetry exists because of the associated importance relative to both injury and performance	The link between some asymmetry tests (e.g., jumps) and sport-specific performance is not consistently evidenced and needs to be further investigated
CMJ, drop jumps and a variety of horizontal hopping tasks can be used to assess asymmetry in jumping and lower limb power tasks	Between-session analysis: during test-retest designs or longitudinal analyses, comparing changes in asymmetry to the preceding CV values would confirm whether changes in the signal (asymmetry) are greater than the noise (CV)	Asymmetry is highly task and metric-specific in nature	The link between some asymmetry tests and the risk of non-contact injuries is not clear, therefore future research is needed to prove the existence of a cause-effect
Bilateral jumps allow for quicker concentric, eccentric velocity, for greater power production and jump height than unilateral CMJ	Direction of asymmetry: asymmetry is a ratio, making it comprised of two individual parts (i.e., dominant and non-dominant limb scores). Thus, when practitioners treat asymmetry as a single number, no context is provided for which limb performed superiorly	Individual, rather than group analysis, has been recommended for asymmetry assessments	Investigations require further standardization of methodology and analysis to optimize interpretation (e.g., within session and between session), adoption, and implementation of inter-limb asymmetry testing and appropriate interventions
While unilateral tasks may not allow for force and power	The reliability of asymmetries should be verified by the	Traditional resistance training, flywheel resistance training and	To develop an understanding and application of interventions

compensation between the limbs during the task, unilateral jumps may be a better measure of "true limb capacity'	practitioners for each test using test-retest analysis (e.g., ICC and CV)	combined training interventions, can reduce lower limb asymmetries	addressing inter-limb asymmetries within the sport, greater methodological rigor should be applied towards study design, data analysis and interpretation of future investigations

NHE = Nordic hamstring exercise; CMJ = Countermovement jumps; CV = Coefficient of variation; ICC = Intraclass correlation coefficient