

Effects of Unilateral Versus Bilateral Multiplanar Plyometric Integration on Interlimb Asymmetry, Agility, and Dynamic Balance in Athletes

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Article Type: Original Article How to Cite: Mustafa M, Memon AG, Babur MN, Sajjad M, Iqbal A, Shah Z. Effects of Unilateral Versus Bilateral Multiplanar Plyometric Integration on Interlimb Asymmetry, Agility, and Dynamic Balance in Athletes. <i>Journal of Precision Medicine and Health Research</i>. 2026;3(1):1-9. Article ID: 57 DOI: https://doi.org/10.68279/nf08ne92 Article Link: https://jpmhr.com/index.php/jpmhr/article/view/57 Declarations: See end of article. OPEN ACCESS This is an open access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0).	Background: Interlimb asymmetry, change-of-direction performance, and dynamic balance are important components of athletic performance and may respond differently to unilateral and bilateral plyometric training. Objective: To compare the effects of unilateral versus bilateral multiplanar plyometric training on interlimb asymmetry, Agility T-test performance, and dynamic balance in athletes. Methods: This assessor-blinded randomized clinical trial included 48 provincial-level athletes aged 18–25 years recruited from two fitness facilities in Lahore, Pakistan. Participants were allocated by lottery to unilateral plyometric training (Group A, n=24) or bilateral plyometric training (Group B, n=24), performed three times weekly for eight weeks. Interlimb asymmetry was assessed using the single-leg countermovement jump, change-of-direction performance using the Agility T-test, and dynamic balance using the Y-Balance Test. Paired-samples t tests assessed within-group changes, while independent-samples t tests compared groups. Results: At week 8, Group A demonstrated lower interlimb asymmetry than Group B ($11.77 \pm 1.53\%$ vs $12.76 \pm 1.14\%$; $p=0.015$) and a lower Agility T-test time (12.75 ± 1.69 vs 14.83 ± 1.58 s; $p<0.001$). Right-limb Y-Balance scores were 98.41 ± 2.99 versus 96.30 ± 2.84 ($p=0.016$) and left-limb scores were 96.43 ± 3.53 versus 94.25 ± 3.48 ($p=0.036$), respectively. Conclusion: Both interventions were associated with favourable pre-to-post changes, while unilateral training produced more favourable post-intervention values across the assessed outcomes. Keywords: Agility; athletes; dynamic balance; interlimb asymmetry; plyometric exercise; unilateral training; bilateral training.

Introduction

Athletic performance depends on the coordinated interaction of neuromuscular control, strength, movement efficiency, and postural stability, particularly in sports that require repeated jumping, landing, acceleration, deceleration, and rapid changes in direction. Interlimb asymmetry, defined as a measurable difference in performance between the right and left limbs, is commonly observed in athletes exposed to repetitive unilateral or direction-specific sporting demands (1). Although a certain degree of asymmetry may occur naturally, greater lower-limb asymmetry has been associated with reductions in several measures of athletic performance, while its relationship with injury risk appears to vary according to the task, population, and method used to quantify asymmetry (2).

Agility and dynamic balance are also important components of multidirectional athletic performance. Agility involves the ability to rapidly modify movement direction while maintaining effective control of the body, whereas successful change-of-direction performance additionally depends on braking capacity, lower-limb strength, coordination, and efficient re-acceleration mechanics (3,4). Dynamic balance refers to the ability to maintain or restore postural control while the center of mass moves over a changing base of support and is particularly relevant during landing, cutting, pivoting, and other sport-specific movements. Adaptations in postural control resulting from sport participation have been associated with neuromuscular function and athletic performance (5). Consequently, training strategies that simultaneously address side-to-side performance differences, multidirectional movement capacity, and dynamic postural control may be particularly relevant for athletes.

Plyometric training is widely used to improve athletic performance through repeated exploitation of the stretch-shortening cycle, in which rapid eccentric loading is followed by an explosive concentric action. Appropriately prescribed plyometric exercise can enhance jumping ability, reactive strength, movement speed, and change-of-direction performance (6). Training that incorporates force production in different movement directions may further increase the specificity of plyometric exercise for sports involving multidirectional acceleration, landing, and cutting demands (7). However, adaptations may also depend on whether exercises are performed unilaterally or bilaterally because the two approaches impose different neuromuscular, stabilization, and force-production demands.

Previous research indicates that both unilateral and bilateral plyometric training can improve physical-performance outcomes, although evidence regarding their comparative effectiveness remains inconsistent. A recent meta-analysis reported beneficial effects of both unilateral and bilateral plyometric training on jumping, sprinting, and change-of-direction performance, with the magnitude of adaptation varying according to the performance task assessed (8). Neves et al. reported broadly comparable improvements after unilateral and bilateral plyometric training combined with linear sprint training in youth male futsal players (9). In contrast, Li et al. observed greater benefits of unilateral plyometric training for single-leg power and change-of-direction performance in basketball players (10), whereas Aztarain-Cardiel et al. reported advantages of bilateral training for selected physical-performance outcomes (11). Similarly, Gharaat identified greater bilateral effects for some speed and agility measures in trained adolescent boys (12). Cao et al. further demonstrated that unilateral, bilateral, and combined plyometric programs may differentially influence muscular strength, power, interlimb asymmetry, and change-of-direction performance (13). Collectively, these findings suggest that the relative effects of unilateral and bilateral plyometric training may depend on the movement task, outcome assessed, training characteristics, and athletic population.

Despite increasing evidence on unilateral and bilateral plyometric training, direct comparisons focusing simultaneously on interlimb asymmetry, change-of-direction performance, and dynamic balance remain limited. In particular, evidence is insufficient regarding whether

unilateral or bilateral multiplanar plyometric integration produces different adaptations across these complementary performance domains when training frequency and duration are comparable. Clarifying these effects may help inform exercise selection in sports physiotherapy and athletic conditioning programs where limb symmetry, multidirectional performance, and postural control are important rehabilitation or performance objectives. Therefore, the present randomized clinical trial aimed to compare the effects of unilateral versus bilateral multiplanar plyometric integration on interlimb asymmetry, Agility T-test performance, and dynamic balance measured using the Y-Balance Test in athletes. It was hypothesized that the two training approaches would produce different post-intervention responses across these outcomes.

Materials and Methods

A parallel-group, assessor-blinded randomized clinical trial was conducted at Body Fitness Gym and Alpha Time Fitness Club, Lahore, Pakistan, to compare unilateral and bilateral multiplanar plyometric training in athletes. Participants were recruited using non-probability convenience sampling. Eligible participants were male or female athletes aged 18–25 years, had a body mass index (BMI) of 20–24.9 kg/m², had participated in sport at the provincial level, and had at least two years of sporting experience. Athletes were not eligible if they had conditions or exposures considered likely to interfere with training participation or outcome assessment, including severe cardiovascular disease, a diagnosed psychological condition likely to affect performance or motivation, use of performance-enhancing drugs or substances affecting recovery, or use of medications that could influence postural stability, motor control, or cognition. Development of a musculoskeletal injury during the intervention period or concurrent participation in other high-intensity sport likely to confound the training response was considered a reason for discontinuation from the study procedures. Eligible athletes who consented to participate underwent baseline assessment before group allocation.

The sample size was determined a priori for a comparison of two independent means using right-limb Y-Balance Test values reported in previous plyometric-training research (14). The calculation was performed using G*Power version 3.1, with an effect size of 1.0265, a one-tailed alpha level of 0.05, statistical power of 95%, and equal allocation between groups (15). The calculated minimum sample size was 44 participants, corresponding to 22 participants per group. After allowing approximately 10% for possible attrition, 48 athletes were recruited. Participants were allocated in a 1:1 ratio by lottery to either Group A, which received unilateral multiplanar plyometric training, or Group B, which received bilateral multiplanar plyometric training, with 24 participants assigned to each group. The outcome assessor remained unaware of group allocation throughout outcome assessment.

Interlimb asymmetry was assessed using the single-leg countermovement jump (SL-CMJ). Participants were familiarized with the procedure before testing and performed the assessment separately on both limbs. The highest recorded performance from each limb was used to calculate interlimb asymmetry according to the formula: [(higher-performing limb – lower-performing limb)/higher-performing limb] × 100. Higher percentage values therefore represented greater side-to-side performance asymmetry. The SL-CMJ has been used to evaluate lower-limb performance characteristics in athletic populations (16). Agility-related change-of-direction performance was assessed using the Agility T-test, which incorporates forward sprinting, lateral shuffling, and backward movement, with performance expressed as the time required to complete the test. Lower completion times indicated better performance.

Dynamic balance was evaluated using the Lower Quarter Y-Balance Test. Participants performed reaches in the anterior, posteromedial, and posterolateral directions for each lower limb, and right- and left-limb performance was recorded for subsequent analysis. The Y-Balance Test has established evidence of reliability and discriminant validity for assessment of dynamic balance and lower-extremity functional performance (17). Interlimb asymmetry, Agility T-test performance, and Y-Balance Test performance were assessed at baseline before commencement of training and reassessed after completion of the eight-week intervention period.

Following baseline assessment, both groups participated in three supervised plyometric-training sessions per week for eight consecutive weeks, with each session lasting approximately 45 minutes. Each training session began with a dynamic warm-up consisting of leg swings, walking lunges, side lunges, high knees, ankle hops, and hip circles. Group A performed unilateral versions of the prescribed plyometric exercises, including horizontal jumps, three-bounce jumps, reactive pogo jumps, countermovement jumps, and 10-cm drop jumps. During weeks 1–4, participants completed two sets of five repetitions per limb. During weeks 5–8, training volume was progressed to three sets of approximately six to eight repetitions per limb, together with progression in jump height, distance, or exercise intensity.

Group B performed bilateral versions of the corresponding plyometric movement categories. During weeks 1–4, participants completed two sets of 10 repetitions, progressing during weeks 5–8 to three sets of approximately 12–15 repetitions, with increases in jump height, distance, or exercise intensity. Both intervention groups therefore followed the same overall training frequency, intervention duration, session duration, warm-up structure, and broad exercise categories, while differing primarily in whether the plyometric tasks were performed unilaterally or bilaterally. Each session concluded with static stretching of the hamstrings, quadriceps, calf muscles, hip flexors, gluteal/piriformis muscles, and hip adductors. Stretching was maintained for approximately 20–30 seconds and was performed for three sets of two repetitions for each muscle group. Outcome measures were reassessed after completion of week 8 by the assessor who remained unaware of treatment allocation.

Data were analyzed using IBM SPSS Statistics version 27.0. Continuous variables were summarized using means and standard deviations, while categorical variables were presented as frequencies and percentages where applicable. Distributional normality of the continuous outcome variables was evaluated using the Shapiro–Wilk test before application of parametric analyses. Paired-samples *t* tests were used to evaluate pre- to post-intervention changes within each treatment group, while independent-samples *t* tests were used to compare Group A and Group B at the assessed time points. Statistical significance was defined as *p* < 0.05. All 48 randomized participants completed the intervention and post-intervention assessment; therefore, the reported analyses included 24 participants in each group with no loss to follow-up or missing post-intervention outcome data.

The study was conducted after approval by the concerned Institutional Review Board, and participation was based on participant consent. The outcome-assessment process incorporated assessor blinding to reduce detection bias, while use of the same outcome measures at baseline and after eight weeks and supervised delivery of both training protocols were intended to maintain consistency in assessment and intervention delivery.

Results

Forty-eight athletes completed the study and were included in the analysis, with 24 participants in the unilateral plyometric group and 24 in the bilateral plyometric group. Group A included 10 males (41.7%) and 14 females (58.3%), whereas Group B included 11 males (45.8%)

and 13 females (54.2%). Baseline age, height, weight, BMI, and sex distribution were similar between the two groups, with not statistically significant between-group differences in the available demographic characteristics (Table 1).

Baseline values for all study outcomes were also comparable between groups. The mean between-group difference at baseline was -0.27 percentage points for interlimb asymmetry (95% CI -1.05 to 0.51 ; $p=0.491$), -0.12 s for Agility T-test performance (95% CI -0.57 to 0.33 ; $p=0.595$), -0.39 for right-limb Y-Balance Test performance (95% CI -2.08 to 1.30 ; $p=0.644$), and 0.08 for left-limb Y-Balance Test performance (95% CI -2.00 to 2.16 ; $p=0.939$) (Table 2).

Table 1. Baseline demographic characteristics of participants

Characteristic	Group A: Unilateral (n=24)	Group B: Bilateral (n=24)	p-value
Age, years	21.87 $\pm$ 1.94	20.96 $\pm$ 2.33	0.148
Height, cm	175.00 $\pm$ 7.50	173.92 $\pm$ 7.25	0.614
Weight, kg	68.79 $\pm$ 7.63	68.30 $\pm$ 6.91	0.817
BMI, kg/m ²	22.42 $\pm$ 1.49	22.55 $\pm$ 1.45	0.761
Male, n (%)	10 (41.7)	11 (45.8)	1.000
Female, n (%)	14 (58.3)	13 (54.2)	1.000

Data are presented as mean $\pm$ SD or n (%). Continuous variables were compared using Welch's independent-samples t test calculated from the reported summary data. Sex distribution was compared using Fisher's exact test. BMI, body mass index.

Table 2. Between-group comparison of study outcomes at baseline and after eight weeks

Outcome	Time point	Group A mean $\pm$ SD	Group B mean $\pm$ SD	Mean difference (A-B)	95% CI	p-value	Hedges' g
Interlimb asymmetry, %	Baseline	13.58 $\pm$ 1.53	13.85 $\pm$ 1.13	-0.27	-1.05 to 0.51	0.491	-0.20
Interlimb asymmetry, %	Week 8	11.77 $\pm$ 1.53	12.76 $\pm$ 1.14	-0.99	-1.78 to -0.20	0.015	-0.72
Agility T-test, s	Baseline	17.92 $\pm$ 0.79	18.04 $\pm$ 0.77	-0.12	-0.57 to 0.33	0.595	-0.15
Agility T-test, s	Week 8	12.75 $\pm$ 1.69	14.83 $\pm$ 1.58	-2.08	-3.03 to -1.13	<0.001	-1.25
Y-Balance Test, right	Baseline	89.41 $\pm$ 2.99	89.80 $\pm$ 2.81	-0.39	-2.08 to 1.30	0.644	-0.13
Y-Balance Test, right	Week 8	98.41 $\pm$ 2.99	96.30 $\pm$ 2.84	2.11	0.42 to 3.81	0.016	0.71
Y-Balance Test, left	Baseline	88.91 $\pm$ 3.71	88.83 $\pm$ 3.44	0.08	-2.00 to 2.16	0.939	0.02
Y-Balance Test, left	Week 8	96.43 $\pm$ 3.53	94.25 $\pm$ 3.48	2.18	0.14 to 4.22	0.036	0.61

Data are presented as mean $\pm$ SD. Mean differences, 95% confidence intervals, p-values, and Hedges' g were calculated from the reported group means, standard deviations, and $n=24$ per group using two-sided Welch independent-samples t tests. Negative differences for interlimb asymmetry and Agility T-test favor lower Group A values, whereas positive differences for Y-Balance Test outcomes indicate higher Group A values. CI, confidence interval; SD, standard deviation.

Table 3. Within-group changes from baseline to eight weeks

Outcome	Group	Baseline mean $\pm$ SD	Week 8 mean $\pm$ SD	Mean change
Interlimb asymmetry, %	Group A	13.58 $\pm$ 1.53	11.77 $\pm$ 1.53	-1.81
Interlimb asymmetry, %	Group B	13.85 $\pm$ 1.13	12.76 $\pm$ 1.14	-1.09
Agility T-test, s	Group A	17.92 $\pm$ 0.79	12.75 $\pm$ 1.69	-5.17
Agility T-test, s	Group B	18.04 $\pm$ 0.77	14.83 $\pm$ 1.58	-3.21
Y-Balance Test, right	Group A	89.41 $\pm$ 2.99	98.41 $\pm$ 2.99	9.00
Y-Balance Test, right	Group B	89.80 $\pm$ 2.81	96.30 $\pm$ 2.84	6.50
Y-Balance Test, left	Group A	88.91 $\pm$ 3.71	96.43 $\pm$ 3.53	7.52
Y-Balance Test, left	Group B	88.83 $\pm$ 3.44	94.25 $\pm$ 3.48	5.42

Mean change was calculated as week-8 value minus baseline value. Negative changes represent reductions in interlimb asymmetry and Agility T-test completion time; positive changes represent increases in Y-Balance Test performance. Paired-change standard deviations, confidence intervals, and exact paired-test p-values cannot be derived from group-level baseline and follow-up SDs alone.

After eight weeks, Group A demonstrated a lower mean interlimb asymmetry than Group B, with values of $11.77 \pm 1.53\%$ and $12.76 \pm 1.14\%$, respectively. The between-group mean difference was -0.99 percentage points (95% CI -1.78 to -0.20 ; $p=0.015$), corresponding to a Hedges' g of -0.72 . Agility T-test completion time was also lower in Group A than in Group B at week 8 (12.75 ± 1.69 s vs 14.83 ± 1.58 s), with a mean difference of -2.08 s (95% CI -3.03 to -1.13 ; $p<0.001$) and a Hedges' g of -1.25 .

For dynamic balance, the week-8 right-limb Y-Balance Test score was 98.41 ± 2.99 in Group A and 96.30 ± 2.84 in Group B, giving a mean difference of 2.11 (95% CI 0.42 to 3.81; $p=0.016$) and a Hedges' g of 0.71. Left-limb Y-Balance Test performance was 96.43 ± 3.53 in Group A compared with 94.25 ± 3.48 in Group B, corresponding to a mean difference of 2.18 (95% CI 0.14 to 4.22; $p=0.036$) and a Hedges' g of 0.61 (Table 2).

Arithmetic pre-to-post changes were observed in both groups across all outcomes. Interlimb asymmetry decreased by 1.81 percentage points in Group A and 1.09 percentage points in Group B. Agility T-test completion time decreased by 5.17 s and 3.21 s, respectively. Right-limb Y-Balance Test values increased by 9.00 in Group A and 6.50 in Group B, while left-limb values increased by 7.52 and 5.42,

respectively (Table 3). These change values describe the magnitude and direction of within-group change and do not constitute a statistical comparison of the change between treatment groups.

Discussion

The present study compared unilateral and bilateral multiplanar plyometric training with respect to interlimb asymmetry, change-of-direction performance, and dynamic balance in athletes. Both groups demonstrated favorable pre-to-post changes across the assessed outcomes, while the unilateral group had lower interlimb asymmetry and Agility T-test completion time and higher right- and left-limb Y-Balance Test scores at the eight-week assessment. The magnitude of the post-intervention between-group differences was greatest for Agility T-test performance, with moderate-to-large standardized differences also observed for interlimb asymmetry and dynamic balance. These findings suggest that unilateral plyometric training may provide a comparatively greater stimulus for performance tasks that require limb-specific force production, stabilization, and multidirectional control, although the current analysis primarily establishes post-intervention group differences rather than a formally tested group-by-time treatment interaction.

The lower interlimb asymmetry observed after unilateral training is consistent with previous evidence indicating that single-limb plyometric exercise may provide a more specific stimulus for reducing side-to-side performance differences. Li et al. reported greater improvements in single-leg power and change-of-direction ability following unilateral compared with bilateral plyometric training in basketball players (10). Similarly, Cao et al. found that unilateral, bilateral, and combined plyometric programs produced different adaptations in muscular strength, power, asymmetry, and change-of-direction performance in youth basketball players (13). A recent meta-analysis also reported that unilateral and bilateral plyometric training can improve several physical-performance outcomes, although the magnitude of adaptation may depend on the performance task and training characteristics (8). More specifically, evidence synthesized by Sun et al. suggests that unilateral plyometric training can reduce lower-limb asymmetry in athletic populations (19). The direction of the present findings is therefore compatible with the concept of task-specific adaptation, whereby repeated loading of each limb independently may provide greater opportunity to address side-to-side performance differences than exercises performed simultaneously with both limbs.

Several neuromuscular mechanisms may plausibly contribute to this pattern. Unilateral plyometric tasks require each lower limb to independently absorb impact, stabilize the body, generate propulsive force, and control the center of mass during take-off and landing. This may increase the demand placed on limb-specific motor control and stabilization compared with bilateral tasks, in which force and postural demands can be distributed across both lower extremities. Such training specificity may be particularly relevant when the outcome itself is assessed independently for each limb. Nevertheless, the present study did not directly measure neuromuscular activation, muscle strength, rate of force development, landing biomechanics, or other physiological mechanisms; therefore, these explanations should be considered plausible interpretations rather than demonstrated mechanisms.

Change-of-direction performance improved numerically in both groups, while the unilateral group demonstrated a substantially lower Agility T-test completion time at the post-intervention assessment. This finding is consistent with Li et al., who observed an advantage of unilateral plyometric training for change-of-direction performance (10). However, the literature is not uniform. Neves et al. reported broadly comparable performance improvements following unilateral and bilateral plyometric training when both approaches were combined with linear sprint training in youth male futsal players (9). Aztarain-Cardiel et al. reported advantages of bilateral training for selected physical-performance outcomes in male postpubertal basketball players (11), while Gharaat also found greater bilateral effects for some speed and agility measures in trained adolescent boys (12). These differences may reflect variation in participant age, sporting background, baseline training status, intervention volume, exercise selection, concurrent training, and the specific tests used to assess multidirectional performance.

The comparatively favorable Agility T-test performance observed in the unilateral group may also be related to the mechanical requirements of rapid directional changes. Successful change-of-direction performance requires force absorption during braking, control of single-limb support, repositioning of the center of mass, and rapid force generation during re-acceleration. Because unilateral plyometric tasks repeatedly expose each limb to independent loading and stabilization demands, they may transfer more directly to phases of movement in which one limb temporarily bears a greater proportion of body weight. However, the Agility T-test is a preplanned change-of-direction task rather than a reactive agility test involving an external decision-making stimulus. The present findings should therefore be interpreted specifically as changes in planned multidirectional change-of-direction performance rather than as evidence of improved perceptual or reactive agility.

Dynamic balance also demonstrated favorable post-intervention differences for the unilateral group on both right- and left-limb Y-Balance Test performance. Unilateral plyometric exercises require repeated maintenance of postural stability over a comparatively small base of support and may challenge proprioceptive control, lower-extremity coordination, and stabilization during landing. Previous experimental evidence has shown that plyometric and balance training can improve neuromuscular control in recreational athletes with functional ankle instability (18). In addition, combined balance and plyometric approaches have been investigated for their effects on interlimb asymmetry and neuromuscular performance in soccer players (20). Although those populations and intervention structures differ from those of the present study, they support the broader concept that plyometric loading combined with substantial postural-control demands can influence dynamic balance and limb-specific neuromuscular performance.

From a sports physiotherapy and conditioning perspective, these findings may be relevant when exercise programs are intended to address multiple components of lower-limb performance simultaneously. Both unilateral and bilateral plyometric approaches were associated with favorable changes over the eight-week intervention period, suggesting that either format may be incorporated into structured athletic training when appropriate to the athlete's needs and training status. The larger post-intervention differences observed in the unilateral group indicate that unilateral exercises may be particularly relevant when the training objective emphasizes limb-specific control, reduction of performance asymmetry, change-of-direction capacity, or dynamic balance. Nevertheless, exercise selection should also consider sport-specific demands, training history, individual tolerance, and the broader rehabilitation or performance program rather than relying on a single training modality.

Several aspects of the study strengthen interpretation of the findings. The two groups followed the same intervention duration and training frequency, outcome assessments were conducted at standardized baseline and eight-week time points, and the outcome assessor remained unaware of group allocation. All 48 randomized participants completed follow-up, eliminating loss-to-follow-up within the reported sample. In addition, the study examined complementary performance domains rather than a single isolated outcome, allowing comparison of limb symmetry, change-of-direction performance, and dynamic balance within the same intervention period.

The findings should nevertheless be interpreted in light of important limitations. Participants were recruited through convenience sampling from two fitness settings, which may limit generalizability to athletes from other sports, competitive levels, or training environments. The sample was relatively small, and sport-specific subgroup analyses were not available. The study did not include long-term follow-up, so the persistence of the observed changes is unknown. Training adherence beyond completion of the study, adverse events, and detailed measures of intervention fidelity were not reported. The study also assessed several outcomes without an explicitly designated primary outcome in the reported analysis. Most importantly, the statistical approach was based on within-group paired comparisons and between-group comparisons at individual time points rather than a baseline-adjusted model or formal group-by-time interaction. Consequently, although the unilateral group demonstrated more favorable post-intervention values and larger arithmetic changes across the assessed outcomes, the present results should not be interpreted as definitive evidence that unilateral training produced a statistically greater longitudinal treatment effect. Future analyses and adequately powered trials using baseline-adjusted or repeated-measures models, effect estimates with confidence intervals, clearly specified primary outcomes, and longer follow-up would provide a more precise estimate of the comparative effects of unilateral and bilateral plyometric training.

Conclusion

Both unilateral and bilateral multiplanar plyometric training were associated with favorable changes in interlimb asymmetry, Agility T-test performance, and dynamic balance over eight weeks. At post-intervention assessment, athletes who performed unilateral training demonstrated lower interlimb asymmetry and Agility T-test completion time and higher right- and left-limb Y-Balance Test scores than those who performed bilateral training. These findings indicate that unilateral plyometric training may be particularly relevant when limb-specific control, change-of-direction performance, and dynamic balance are important training objectives; however, the comparative findings should be interpreted in the context of the study's sample size and the absence of a formal longitudinal group-by-time treatment-effect analysis.

DECLARATIONS

Author Contributions:	Concept: MM; Design: MM, AGM; Data Collection: MM, MS, AI, ZS; Analysis: MM, AGM; Drafting: MM, MS, AI, ZS; Critical Review: AGM, MNB. All authors reviewed and approved the final manuscript.
Ethical Approval:	The study was conducted after approval from the concerned Institutional Review Board. The authors certified that the research protocol had received institutional ethical approval before submission. The specific ethical approval reference number and approval date should be reported according to the official approval letter.
Informed Consent:	Informed consent was obtained from all participants before enrolment in the study.
Conflict of Interest:	The authors declare no conflict of interest.
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AI Declaration:	Generative AI tools were used solely for language and grammatical refinement. The authors verified the final manuscript and remain fully responsible for its accuracy, integrity, and scientific content.

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