

The Effects of a Strength Training Program on Bilateral Jump Performance in Collegiate 100m and 1500m Runners

Tran Thanh Hoai

Center for Physical and National Defense Education, Electric Power University, Hanoi, Vietnam

HOW TO CITE:

Tran Thanh Hoai (2026). The Effects of a Strength Training Program on Bilateral Jump Performance in Collegiate 100m and 1500m Runners. International Journal of Special Education, 41(17s), 665-672

COPYRIGHT STATEMENT:

Copyright: © 2026 Authors.
Open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

ABSTRACT:

This study examined whether a 12-week strength-training program improves bilateral jump performance in collegiate runners from sprint (100 m) and middle-distance (1500 m) squads. Thirty-one athletes (18–21 years) from Electric Power University completed pre- and post-testing using squat jump in place (JIP) and one-step run-up jump (JR-U) on a ChronoJump contact mat; body composition was assessed with the InBody 770 analyzer. Normality was checked with Shapiro–Wilk; pre–post changes were evaluated using paired t-tests ($\alpha = 0.05$). Female 1500 m runners demonstrated significant gains in JIP ($p = 0.031$) and JR-U ($p = 0.026$) and reduced JR-U asymmetry ($p = 0.004$), whereas changes in male athletes and female sprinters were not significant, suggesting event- and sex-specific responsiveness and potential prior adaptation among sprinters. These findings indicate that targeted strength blocks may be prioritized for female middle-distance athletes to enhance jump ability and inter-limb symmetry, while jump-asymmetry indices can serve as sensitive monitoring markers. The study received institutional ethics approval (EPU.CS11/2023), and all participants provided written informed consent.
Keywords: Resistance training, lower-limb asymmetry, collegiate athletes, sprint performance, middle-distance running

1. Introduction

Lower-limb muscular strength plays a critical role in maintaining postural stability, mitigating ground reaction forces, and generating propulsion during running (Weyand et al., 2000; Slawinski et al., 2010). Enhancing this strength through targeted resistance training has been shown to positively impact running performance, making it a central focus in athletic conditioning programs (Markovic & Mikulic, 2010; Buchheit & Laursen, 2013).

However, bilateral strength asymmetry - differences in strength between the two legs - can

negatively affect running efficiency and performance (Fort-Vanmeerhaeghe et al., 2020; Plisky et al., 2006). Such asymmetry is considered a key performance indicator, as it correlates with discrepancies in step length and force production between the dominant and non-dominant limbs (Sasek et al., 2024). Contributing factors may include biomechanical structure, gait patterns, and training history, though resistance exercises have been shown to reduce this imbalance (Bazylar et al., 2014; Bautista et al., 2021).

Jump performance assessments are frequently used to evaluate lower-limb power and inter-limb asymmetry (Cohen et al., 2020). Notably, single-

leg jumps offer a more precise measure of unilateral leg power, while double-leg jumps may mask asymmetries due to compensatory mechanisms (Cohen et al., 2020).

This study aims to investigate the effects of a 12-week strength training program on inter-limb asymmetry and jump performance in 100m and 1500m runners from Electric Power University. The findings are expected to provide empirical evidence on the efficacy of strength training interventions in enhancing jump performance and potentially improving running efficiency in short- and middle-distance events.

2. Methodology

Ethics Committee Approval

This study received ethics approval under the 2023 institutional research plan and was conducted during the 2023–2024 academic year under institutional approval code EPU.CS11/2023. All participants were fully informed about the study's objectives, procedures, and requirements prior to participation. Written informed consent was obtained, and participants agreed voluntarily to take part and comply with the study protocols. All collected data were kept confidential and used solely for research purposes.

Participants

Thirty-one collegiate track athletes (18–21 years; 15 males, 16 females) were recruited from a university team: 1500-m group (8 males, 6 females) and 100-m group (7 males, 10 females). Inclusion criteria were ≥ 2 years of systematic training and medical clearance for maximal-effort testing. Exclusion criteria were lower-limb injury in the prior 6 months or any contraindication to strength/power testing.

Measures

The primary outcomes were jump height (cm) obtained from two tests: (i) squat jump in place (JIP), performed from a fixed knee angle of $\sim 90^\circ$, and (ii) one-step approach jump (JR-U), executed with a single-step approach onto the contact surface followed by a vertical take-off. Jump height was recorded with a ChronoJump contact mat (Din-A2; Chronojump-Boscosystem) using the device's standard flight-time algorithm. For each test, athletes performed three maximal attempts, and the mean of the three was used for analysis.

Inter-limb asymmetry (%) was derived from unilateral performance (higher vs lower side) according to:

$$\text{Asymmetry}(\%) = \frac{\text{Higher} - \text{Lower}}{\text{Higher} + \text{Lower}} \times 100$$

Secondary descriptors included demographic characteristics and body composition collected at each testing session.

Procedures

Before testing, athletes completed a standardized warm-up and familiarization (e.g., moderate-intensity squat jumps and 10-m loaded walk drills). Testing was performed in the following order on the ChronoJump mat: JIP $\rightarrow$ JR-U. For each test, athletes performed two submaximal warm-up trials (≈ 50 – 70% effort) followed by three maximal trials; any trial deviating by ≥ 2.0 cm from the athlete's mean was repeated.

Participants then completed a 12-week strength-training intervention. During week 9, athletes competed in the National Student Athletics Championship (1 week), after which they resumed training and completed post-intervention testing.

Table 1. "Power-up" Training Program 100m Team (12 Weeks)

Week	Phase	Day 1 (Set $\times$ Rep)	%1RM	Day 2 (Set $\times$ Rep)	%1RM	Day 3 (Set $\times$ Rep)	%1RM
1	Base Strength	3 $\times$ 3	77	3 $\times$ 4	75	3 $\times$ 5	80
2		3 $\times$ 3	80	3 $\times$ 4	82	3 $\times$ 5	80

3	Maximum Strength	3×5	85	4×3	90	4×3	85
4		3×4	85	3×5	85	3×4	85
5		3×5	85	4×3	85	4×3	77
6	Speed Strength	3×3	85	3×3	85	3×3	75
7	Speed Strength	3×4	85	3×4	85	3×3	72
8	Speed Strength	3×4	85	3×5	85	3×4	70
9	Competition + Rest	—	—	—	—	—	—
10	Strength Recovery	3×3	82	3×4	83	3×3	80
11	Maximum Strength	3×5	85	3×5	85	3×4	75
12	Maximum Strength	3×4	82	3×5	85	3×4	77

Table 2. "Power-up" Training Program 1500m Team (12 Weeks)

Week	Phase	Day 1 (Set $\times$ Rep)	%1RM	Day 2 (Set $\times$ Rep)	%1RM	Day 3 (Set $\times$ Rep)	%1RM
1	Base Strength	3×5	77	3×5	75	3×8	80
2		3×4	80	3×4	83	3×5	85
3	Maximum Strength	3×4	80	3×4	90	4×4	85
4		3×5	85	3×5	85	3×5	80
5	Speed Strength	3×3	85	3×3	85	3×3	77
6		3×4	85	3×4	85	3×3	75
7	Strength Recovery	3×4	85	3×4	85	3×4	75
8		3×4	85	3×2	80	3×2	70
9	Competition + Rest	—	—	—	—	—	—
10	Maximum Strength	3×4	85	3×5	85	3×5	80
11	Base Strength	3×4	85	3×5	85	3×4	75
12		3×4	85	3×3	85	3×3	77

Analysis

Microsoft Excel 2013 was used for data compilation, and all analyses were performed in IBM SPSS Statistics 22.0. After assessing normality with the Shapiro–Wilk test, within-

3. Results

Baseline characteristics of participants

Table 3. Basic characteristics of participants in both testing sessions

Event	Variable	Male		p	Female		p
		Test 1	Test 2		Test 1	Test 2	
1500m	Height (cm)	170.3 ± 5.0	168.9 ± 6.8	0.689	167.2 ± 7.6	166.1 ± 5.0	0.236
	Body weight (kg)	57.6 ± 3.2	55.7 ± 3.3	0.703	56.7 ± 3.2	54.4 ± 2.9	0.661
	Body fat (%)	21.5 ± 1.3	21.4 ± 1.6	0.567	21.6 ± 1.8	21.6 ± 3.1	0.100
100m	Height (cm)	167.0 ± 3.7	167.7 ± 3.8	0.626	169.7 ± 7.3	170.8 ± 5.1	0.438
	Body weight (kg)	59.1 ± 3.6	56.7 ± 0.8	0.314	56.8 ± 3.9	57.4 ± 3.2	0.672
	Body fat (%)	22.4 ± 0.9	21.4 ± 1.7	0.298	21.9 ± 1.3	22.8 ± 2.1	0.621

Table 3 presents the baseline demographic and body composition data for all participants across both testing sessions. The study involved 31 collegiate athletes (aged 18–21 years), with subgroup analyses conducted by sex and event type (100m vs. 1500m).

Across all groups, there were no statistically significant changes in height, body weight, or body fat percentage from pre- to post-intervention (all $p > 0.05$), indicating physiological stability during the 12-week training period. This consistency reduces the likelihood that external factors or morphological changes confounded the performance-related results.

Notably, although a p -value of 0.236 was observed for height in female 1500m runners, the raw values actually showed a slight decrease (167.2 ± 7.6 cm to 166.1 ± 5.0 cm). This change is statistically non-significant and likely reflects normal measurement variation rather than meaningful physiological change.

In summary, the stable anthropometric characteristics across testing sessions support the reliability of subsequent comparisons in jump performance outcomes.

The jump performance outcomes and bilateral asymmetry for both male and female athletes in the 100m and 1500m groups across two testing sessions are summarized in Table 4.

Table 4. Comparison of jump performance and bilateral asymmetry across testing sessions

Event	Variable	Male			Female		
		Test 1	Test 2	p	Test 1	Test 2	p
1500m	JIP (cm)	29.3±2.9*	29.5±3.7*	0.708	18.7±3.2	22.4±3.5	0.031
	JR-U (cm)	32.8±2.0*	32.3±3.2*	0.494	19.9±3.4*	24.0±4.3	0.026
	JIP Asymmetry (%)	5.0±1.8	4.8±2.1	0.399	7.5±6.0	3.74±2.0	0.099
	JR-U Asymmetry (%)	10.5±4.9	7.8±3.6	0.507	13.1±10.3	8.8±9.5	0.004

100m	JIP (cm)	42.9±5.6*	42.4±4.3*	0.668	24.0±1.8	23.1±1.7	0.107
	JR-U (cm)	46.8±7.1*	48.2±6.6*	0.291	25.6±0.5*	25.8±1.1	0.395
	JIP Asymmetry (%)	2.5±1.9	4.7±1.7	0.226	5.03±1.3	4.3±0.08	0.774
	JR-U Asymmetry (%)	8.7±6.2	6.8±0.9	0.587	6.5±6.2	3.3±1.5	0.537

Note: * indicates statistically significant difference between pre-test and post-test at $p < 0.05$

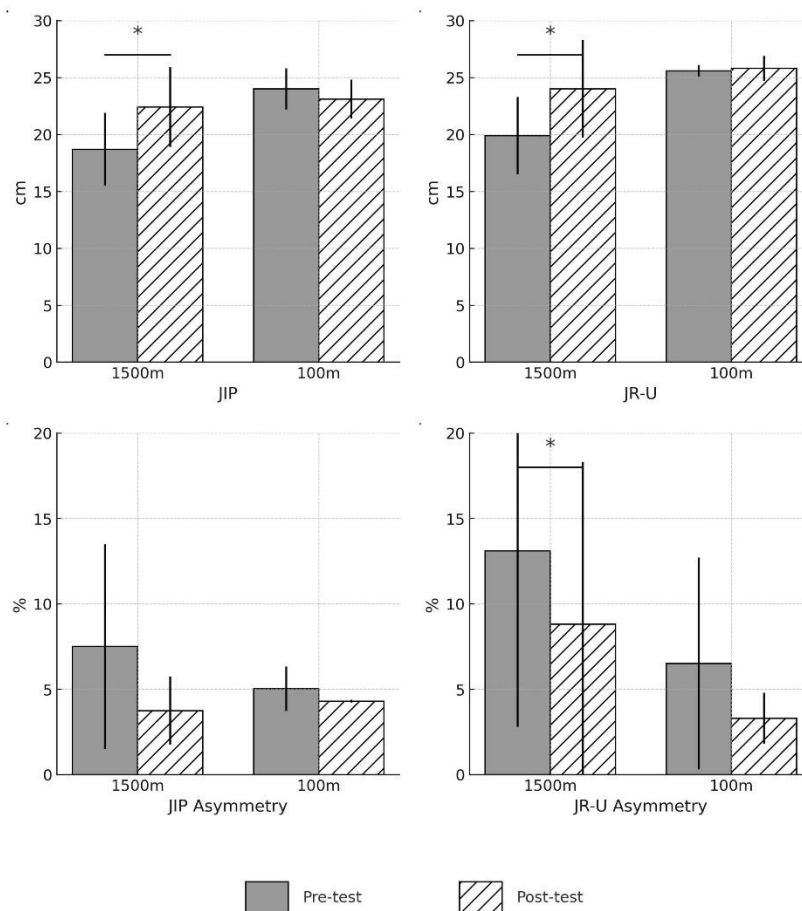
Male athletes

For both the 100m and 1500m male groups, the JIP and JR-U performance remained statistically stable between the two testing sessions ($p > 0.05$). Likewise, no significant changes were observed in asymmetry values for either jump type. These results suggest consistent jump performance and symmetry throughout the testing period.

Female athletes

Figure 1. Female athletes only: JIP and JR-U jump performance (cm) and inter-limb asymmetry (%) in 100-m vs 1500-m runners.

(A) JIP; (B) JR-U; (C) JIP asymmetry; (D) JR-U asymmetry. Bars = mean $\pm$ SD; grey vs hatched denote subgroups as defined in Methods. * indicates $p < 0.05$ within-event between-group differences.



Among 100m female sprinters, neither JIP nor JR-U showed statistically significant changes between sessions ($p > 0.05$), and asymmetry values also remained stable. However, the 1500m

female group exhibited statistically significant improvements in jump performance: JIP increased significantly ($p = 0.031$), JR-U also improved significantly ($p = 0.026$).

In terms of asymmetry, JR-U asymmetry significantly decreased ($p = 0.004$), while JIP asymmetry showed a decreasing trend (from 7.5% to 3.74%) but did not reach statistical significance ($p = 0.099$). These findings suggest positive neuromuscular adaptations among the 1500m female athletes following the intervention period.

Figure 1 illustrates the pre- and post-intervention changes in jump performance and asymmetry for female athletes in both 100m and 1500m groups.

4. Discussion

This study aimed to evaluate the effects of a 12-week strength training program on bilateral jump performance and inter-limb asymmetry in collegiate 100m sprinters and 1500m middle-distance runners. The findings revealed that only the female 1500m group experienced statistically significant improvements in squat jump (JIP) and one-step approach jump (JR-U) performance, along with a notable reduction in JR-U asymmetry. These results suggest that strength training interventions may lead to event- and sex-specific neuromuscular adaptations, with female middle-distance athletes showing greater responsiveness. In contrast, male athletes and female sprinters demonstrated stable performance, possibly due to a training plateau effect or prior neuromuscular conditioning from high-intensity sprint training (Markovic & Mikulic, 2010; Buchheit & Laursen, 2013).

One of the study's major strengths lies in its controlled pre-post design, which minimized bias while standardizing warm-up, jump protocols, and data collection procedures. The use of validated measurement tools such as the ChronoJump Contact Mat and InBody 770 added reliability to the performance and body composition data (Atkinson & Nevill, 2001; Ackerman et al., 2020). Additionally, the analysis of subgroups by sex and event discipline provided granular insights and avoided overgeneralization, allowing for more precise recommendations. Most notably, the inclusion of both jump height and asymmetry indices strengthens our understanding of how bilateral strength differences can be modified through

structured training (Fort-Vanmeerhaeghe et al., 2020; Bazyler et al., 2014).

However, this study is not without limitations. First, the absence of a control group prevents us from isolating the training effect with full confidence, as extraneous factors such as the mid-program competition week could have influenced results. Second, the small sample size in subgroups, especially female 1500m ($n = 6$), limits statistical power and generalizability. Moreover, although p -values were reported, effect sizes and confidence intervals were not provided, making it difficult to evaluate the practical significance of the observed changes (Atkinson & Nevill, 2001). Third, no direct performance measures such as sprint times, stride symmetry, or running mechanics were included, which restricts our ability to relate the observed jump adaptations to actual on-track performance (Slawinski et al., 2010; Weyand et al., 2000).

Future studies should address these limitations by adopting randomized controlled trial (RCT) designs and recruiting larger, more balanced samples across groups. Researchers are encouraged to report Cohen's d effect sizes and 95% confidence intervals to aid interpretation and reproducibility. Including outcome measures such as sprint speed, curved sprint performance, or biomechanical variables (e.g., ground contact time, limb stiffness) would help establish the functional transfer from jump improvements to race performance (Sasek et al., 2024; Kobal et al., 2021; Cohen et al., 2020). Additionally, utilizing EMG analysis, the Star Excursion Balance Test, or fatigue-resistance protocols could offer richer insights into neuromechanical adaptations (Taube et al., 2015; Plisky et al., 2006). Lastly, future research should track athletes beyond the 12-week window to assess the long-term retention of gains in symmetry and jump performance.

In conclusion, this study contributes empirical evidence supporting the application of targeted strength training in female middle-distance runners, highlighting improvements in both vertical jump ability and inter-limb balance. These findings underscore the importance of

individualized training based on sex, distance specialization, and neuromuscular profile (Bautista et al., 2021; Bazyler et al., 2014). Coaches and performance staff should consider tracking lower-limb asymmetry as a valuable diagnostic and monitoring tool - both for performance optimization and injury prevention (Fort-Vanmeerhaeghe et al., 2020; Plisky et al., 2006).

5. Conclusion

Integrating a 12-week strength block appears to improve jump outcomes and cut inter-limb asymmetry in female 1500-m runners, with no convincing changes in men or female 100-m sprinters. Programs should therefore be event- and sex-specific, giving priority to neuromuscular control, bilateral balance, and rate-of-force-development work for female middle-distance athletes. Because body size and composition were stable, coaches should not expect short-term morphological shifts; instead, focus on technique

quality, explosive intent, and asymmetry management. These takeaways need confirmation due to no control group and competition-schedule noise, so future studies should use stronger designs and report effect sizes with CIs. Still, the current data provide actionable support to prioritize structured strength training for female 1500-m runners during the season.

Applicable Remarks

A 12-week strength training program, when combined with actual competition, demonstrated differentiated effects based on sex and running discipline. Specifically, the intervention led to improved jump performance and reduced inter-limb asymmetry in female 1500m runners only. Other groups (male and female sprinters, male middle-distance runners) showed no significant change, highlighting the need for event-specific and gender-sensitive strength programming.

References

- Ackerman, K. E., Holtzman, B., & Solomon, M. (2020). Body composition and health in elite athletes: A comprehensive review. *Sports Med.*, 50(9), 1599–1616.
- Atkinson, G., & Nevill, A. M. (1998). Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. *Sports Med.*, 26(4), 217–238. <https://doi.org/10.2165/0000665-6722665-6722>
- Bautista, I. J., Vicente-Mampel, J., Baraja-Vegas, L., Segarra, V., Martín, F., & Van Hooren, B. (2021). The effects of the Nordic hamstring exercise on sprint performance and eccentric knee flexor strength: A systematic review and meta-analysis of intervention studies among team sport players. *J. Sci. Med. Sport*, 24(9), 931–938. <https://doi.org/10.1016/j.jsams.2021.03.009>
- Bazyler, C. D., Bailey, C. A., Chiang, C.-Y., Sato, K., & Stone, M. H. (2014). The effects of strength training on isometric force production symmetry in recreationally trained males. *J. Trainol.*, 3(1), 6–10. https://doi.org/10.17338/trainology.3.1_6
- Buchheit, M., & Laursen, P. B. (2013). High-intensity interval training, solutions to the programming puzzle: Part I: Sports-specific exercise selection, training intensity, and frequency. *Sports Med.*, 43(5), 313–338. <https://doi.org/10.1007/s4665-672-0029-x>
- Cohen, D., Burton, A., Wells, C., Taberner, M., Diaz, M. A., & Graham-Smith, P. (2020). Single vs double leg countermovement jump tests: Not half an apple! *Aspetar Sports Med. J.*, 9, 34–41.
- Fort-Vanmeerhaeghe, A., Bishop, C., Buscà, B., Aguilera-Castells, J., Serrano, L., & Peña, J. (2020). Inter-limb asymmetries are associated with decrements in physical performance in youth elite team sports athletes. *PLOS One*, 15(3), e0229440. <https://doi.org/10.1371/journal.pone.0229440>
- Kobal, R., Freitas, T. T., Filter, A., Requena, B., Barroso, R., Rossetti, M., Jorge, R. M., Carvalho, L., Pereira, L. A., & Loturco, I. (2021). Curve sprint in elite female soccer players: Relationship with linear sprint and jump performance. *Int. J. Environ. Res. Public Health*, 18(5), 2306. <https://doi.org/10.3390/ijerph18052306>
- Markovic, G., & Mikulic, D. (2010). Complementary training for sprint and jump performance. *Strength Cond. J.*, 32(2), 80–92.

- Plisky, P. J., Rauh, M. J., Kaminski, T. W., & Underwood, F. B. (2006). Star Excursion Balance Test as a predictor of lower extremity injuries in high school basketball players. *J. Orthop. Sports Phys. Ther.*, 36(12), 911–919. <https://doi.org/10.2519/jospt.2006.2244>
- Sašek, M., Šarabon, N., & Smajla, D. (2024). Exploring the relationship between lower-limb strength, strength asymmetries, and curvilinear sprint performance: Findings from a pilot study. *Sci. Prog.*, 107(2), 00368504241247998. <https://doi.org/10.1177/00368504241247998>
- Slawinski, J., Bonnefoy, A., Levêque, J.-M., Ontanon, G., Riquet, A., Dumas, R., & Chèze, L. (2010). The relationship between sprint mechanics and running performance. *J. Appl. Biomech.*, 26(1), 38–46.
- Taube, W., Kullmann, N., & Leukel, C. (2015). Differential effects of learning and fatigue on neuro-mechanical properties. *J. Electromyogr. Kinesiol.*, 25(6), 940–946.
- Weyand, P. G., Sternlight, D. B., Bellizzi, M. J., & Wright, S. (2000). Faster top running speeds are achieved with greater ground forces, not more rapid leg movements. *J. Appl. Physiol.*, 89(5), 1991–1999. <https://doi.org/10.1152/jappl.2000.89.5.1991>

Funding source: This study was internally funded by Electric Power University (Project Code: EPU.CS11/2023). No external sponsors were involved.

Research Ethics: All research-related tasks, including study design, data collection, analysis, writing, and correspondence, were conducted solely by the author.

Conflict of Interest: The author commit to having no conflict of interest related to this study

Acknowledgments: The author would like to express sincere thanks to Electric Power University for funding and facilitating this study (Project Code: EPU.CS11/2023).

Declaration of generative AI and AI-assisted technologies in the writing process:

During the preparation of this work the authors didn't use of AI in the writing of the article