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The Impact of Different Hurdle-Specific Training Modalities on the 110-Meter Hurdle Performance of Sports University Students: An Experimental Study

Liwei Chen

The Postgraduate School, Universitas Pendidikan Ganesha, Singaraja-Bali, 81116, Indonesia

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Abstract: The 110-meter hurdles is a complex event requiring a sophisticated blend of speed, power, technique, and rhythm. While general training principles are well-established, the comparative efficacy of different hurdle-specific training methodologies on the integrated performance of developing athletes warrants further investigation. This study aimed to compare the effects of Traditional Hurdle Training (T-HT) and a novel Rhythm-Based and Plyometric Hurdle Training (RBP-HT) program on the 110-meter hurdle performance of male students at a sports university. A randomized controlled trial was conducted over a 12-week intervention period (January-June 2025). Thirty-two male 110-meter hurdlers from Wuhan Sports University (age: 20.5±1.2 years; height: 181.4±4.1 cm; personal best: 16.50±0.45s) were randomly assigned to either the T-HT group (n=16) or the RBP-HT group (n=16). The T-HT group focused on hurdle drills, lead/trail leg technique, and repetition hurdling. The RBP-HT group emphasized rhythm discrimination drills, assisted and resisted hurdling, and extensive plyometric exercises over hurdles. Primary outcome measures included pre- and post-intervention 110m hurdle time, flying 30m sprint time, and a Hurdle Clearance Efficiency Score (HCES) derived from key technical metrics (take-off distance, landing distance, flight time, hurdle clearance height). Both groups demonstrated significant ($p<0.01$) improvements in all performance metrics from pre- to post-test. However, the RBP-HT group showed significantly greater improvements than the T-HT group in the 110m hurdle time (RBP-HT: -1.21±0.15s vs. T-HT: -0.72±0.18s; $p<0.001$), flying 30m time (RBP-HT: -0.19±0.04s vs. T-HT: -0.09±0.03s; $p<0.01$), and HCES (RBP-HT: +15.3±2.1 points vs. T-HT: +8.1±1.8 points; $p<0.001$). The Rhythm-Based and Plyometric Hurdle Training program was more effective than Traditional Hurdle Training in enhancing the overall 110-meter hurdle performance among sports university students. The findings suggest that integrating advanced rhythm development and plyometric exercises directly into hurdle sessions provides a superior stimulus for improving race speed, flat sprinting capacity, and, most notably, hurdling technique efficiency.

1. Introduction

The 110-meter hurdles is one of the most technically demanding events in track and field. It is not merely a sprint with obstacles but a unique discipline that requires the optimal synthesis of maximal velocity, explosive power, precise motor coordination, and a highly developed sense of rhythm (Mallo, 2012). Success in the event is dictated by an athlete's ability to minimize deceleration and time loss over each of the ten hurdles while maintaining a high sprinting velocity between them [1].

For developing athletes, such as university-level sports students, the foundational elements of hurdling-the lead leg action, trail leg mechanics, and arm-body coordination-are typically the focus of training. Traditional training methodologies (T-HT) often emphasize the repetitive practice of these isolated technical components through drills and hurdle repetitions at sub-maximal and maximal intensities (Schot & Knutzen, 1992). While this approach is effective for establishing basic competency, it may have limitations in fostering the automaticity, reactive strength, and specific rhythm required for elite performance.

Recent trends in hurdle training have explored the integration of more contextual and reactive elements. The concept of "hurdle rhythm" extends beyond a simple three-step pattern; it encompasses the athlete's ability to perceive and adapt to the spatial-temporal demands of the race, allowing for efficient clearance without a breakdown in sprint mechanics (Bridgett & Linthorne, 2006). Furthermore, the hurdle clearance action itself is a plyometric event; the athlete must rapidly switch from an eccentric loading phase during the final foot strike before the hurdle to a concentric explosive action for clearance, followed by another eccentric phase upon landing (Salomon & Strydom, 2020). Training this specific plyometric capacity directly over hurdles, rather than in isolation, could yield significant performance benefits.

Two potential training modalities that align with these concepts are rhythm-based training and hurdle-specific plyometrics. Rhythm training can involve using visual or auditory cues, varying hurdle spacings, and implementing assisted/resisted running to alter the perceptual-motor demands of the task (Coh et al., 2018). Hurdle-specific plyometrics involve exercises like continuous bounding or hopping over hurdles, which enhance reactive strength and leg stiffness specifically in the context of the clearance cycle [2].

Despite the theoretical advantages, there is a scarcity of empirical research directly comparing such an integrated approach against a well-structured traditional training program within a controlled, long-term experimental design, particularly at the university sports level.

Therefore, the purpose of this study was to investigate the effects of two different 12-week training interventions-Traditional Hurdle Training (T-HT) versus a novel Rhythm-Based and Plyometric Hurdle Training (RBP-HT)-on the 110-meter hurdle performance of students at Wuhan Sports University. We hypothesized that both groups would improve their performance, but the RBP-HT group would demonstrate significantly greater improvements in overall race time, flat sprint speed, and technical hurdling efficiency.

2. Methods

2.1. Participants

A total of thirty-two (N=32) male 110-meter hurdlers from the undergraduate programs at Wuhan Sports University were recruited as participants. The sample size was determined a priori using G*Power software (version 3.1.9.7) for a mixed-design ANOVA (within-between interaction), with an assumed effect size $f=0.25$, $\alpha=0.05$, power $(1-\beta)=0.80$, resulting in a minimum of 28 participants. Thirty-two were recruited to account for potential attrition.

Inclusion criteria were: (1) aged 19-23 years; (2) active participation in university-level track and field training for at least two years; (3) a personal best time in the 110m hurdles between 15.80 and 17.20 seconds; (4) free from any musculoskeletal injury for the past six months. Participants were informed of the study's purpose, procedures, and potential risks, and all provided written informed consent. The study was approved by the Institutional Review Board of Wuhan Sports University (Ethics Code: WSU-PE-2024-11).

The participants were randomly assigned to one of two experimental groups using a computer-generated random number sequence: the Traditional Hurdle Training group (T-HT, n=16) and the Rhythm-Based and Plyometric Hurdle Training group (RBP-HT, n=16). There were no significant differences in age, height, body mass, or initial 110m hurdle performance between the groups at baseline ($p > 0.05$), indicating successful randomization (Table 1).

Table 1. Participant Baseline Characteristics (Mean±SD)

Characteristic	T-HT Group (n=16)	RBP-HT Group (n=16)	p-value
Age (years)	20.4±1.3	20.6±1.1	0.642
Height (cm)	180.9±4.5	181.8±3.7	0.531
Body Mass (kg)	73.1±5.2	74.3±4.8	0.501
110m Hurdle PB (s)	16.55±0.48	16.45±0.42	0.527

2.2. Experimental Design

This study employed a randomized controlled trial design with pre- and post-testing. The total duration of the study was 24 weeks, comprising a 4-week preparatory and familiarization phase (January 2025), a 12-week specialized intervention period (February - April 2025), a 1-week tapering period, and final post-testing in mid-May 2025. Data analysis and write-up were completed in June 2025. Both groups trained four times per week, with training sessions matched for total volume and duration (~90 minutes). The groups trained on separate days to prevent cross-contamination of interventions.

2.3. Training Interventions

2.3.1. Traditional Hurdle Training (T-HT) Group

The T-HT program was based on established hurdle training principles, focusing on technical mastery through repetition.

Session Structure: Warm-up (dynamic stretching, sprint drills), Main Block 1 (Hurdle Drills: 4x5 hurdles for lead leg, trail leg, and walk-overs), Main Block 2 (Hurdle Repetitions: e.g., 5x3 hurdles at 90% effort, 3x5 hurdles at 85% effort, 2x8 hurdles at race pace), and Cool-down.

Key Focus: Perfecting the kinematics of the lead leg (fast, high-knee action), trail leg (tight, heel-to-buttock path, flat-sideways clearance), and arm action. Feedback was primarily technical and coach-directed.

2.3.2. Rhythm-Based and Plyometric Hurdle Training (RBP-HT) Group

The RBP-HT program was designed to enhance rhythm perception and reactive strength specifically in the hurdle context.

Session Structure: Warm-up (identical to T-HT), Main Block 1 (Rhythm & Perception Drills), Main Block 2 (Plyometric & Contextual Hurdling).

Rhythm & Perception Drills: Variable Spacing: Hurdles were set at alternating "close-in" and "normal" distances to disrupt a fixed stride pattern and force adaptation. Assisted Hurdling: Using a lightweight resistance band for towed assistance to experience supra-maximal speeds and a faster rhythm. Resisted Hurdling: Using a parachute or sled for mild resistance to develop power and force production into and off the hurdles.

Plyometric & Contextual Hurdling: Continuous Bounding: 2-3 sets of 5-7 hurdles, focusing on maximal horizontal distance and a rapid ground contact time. Alternate Leg Bounding (Speed Hops): Over 5-10 hurdles, emphasizing a powerful, cyclical action mimicking the sprint-hurdle cycle. Hurdle Complexes: e.g., Performing a plyometric bound over one hurdle immediately followed by a sprint clearance over the next.

2.4. Testing Procedures

Pre- and post-testing was conducted over two days under standardized weather conditions (minimal wind, temperature 18-22 ℃) on an official synthetic track.

Day 1:Anthropometrics: Height and body mass were measured. Flying 30m Sprint Test: Participants built up speed over a 40m acceleration zone, and their time for the 30m segment (from 40m to 70m) was recorded using wireless photocells (Brower Timing Systems, USA). The best of two trials was recorded.

Day 2:110m Hurdles Time Trial: Participants completed a full 110m hurdles race (hurdle height: 1.067m) from starting blocks. Time was recorded using fully automated timing gates. Two trials were performed with full recovery, and the faster time was used for analysis.

Hurdle Clearance Efficiency Score (HCES): During the time trial, the clearance of the 4th hurdle was recorded using a high-speed camera (240 fps, Casio Exilim EX-ZR1000) placed perpendicular to the hurdle. Video analysis software (Kinovea, version 0.9.5) was used to calculate four key technical variables: Take-off Distance (m): Horizontal distance from the take-off foot's last contact to the hurdle base. Landing Distance (m): Horizontal distance from the hurdle base to the landing foot's first contact. Flight Time (s): Time from take-off to landing over the hurdle.

Clearance Height (m): Vertical distance between the lowest point of the athlete's center of mass during clearance and the top of the hurdle.

A composite HCES was then calculated using a formula that weighted these variables for optimal efficiency (e.g., closer take-off/landing distances, shorter flight time, and minimal clearance height are preferable). A higher HCES indicates better technical efficiency.

2.5. Statistical Analysis

All data are presented as mean ± standard deviation (SD). The normality of data distribution was confirmed using the Shapiro-Wilk test. A two-way mixed-design ANOVA (Group [T-HT, RBP-HT] x Time [Pre, Post]) was used to analyze the effects of the intervention on the dependent variables (110m time, Flying 30m time, HCES). If a significant interaction effect was found, paired-sample t-tests (within-group) and independent-sample t-tests (between-group at post-test) were used for post-hoc analysis. Effect sizes were calculated using partial eta squared (ηp^2) for ANOVA and Cohen's d for t-tests. The alpha level for statistical significance was set at $p<0.05$. All analyses were performed using SPSS Statistics version 28.0 (IBM Corp., USA).

3. Results

All 32 participants completed the 12-week intervention and post-testing, resulting in no dropouts and a 100% adherence rate.

3.1. 110-Meter Hurdle Performance

The two-way mixed ANOVA revealed a significant main effect for Time ($F(1, 30)=895.4$, $p<0.001$, $\eta p^2=0.968$) and a significant Group x Time interaction ($F(1, 30)=68.1$, $p<0.001$, $\eta p^2=0.694$). Post-hoc analysis confirmed that both groups significantly improved their 110m hurdle time from pre- to post-test (T-HT: -0.72±0.18s, $p<0.001$; RBP-HT: -1.21±0.15s, $p<0.001$). Crucially, the improvement in the RBP-HT group was significantly greater than that in the T-HT group ($p<0.001$) (Table 2).

3.2. Flying 30-Meter Sprint Performance

For the flying 30m test, there was a significant main effect for Time ($F(1, 30)=212.3$, $p<0.001$, $\eta p^2=0.876$) and a significant Group x Time interaction ($F(1, 30)=45.2$, $p<0.001$, $\eta p^2=0.601$). Post-hoc tests showed that both groups improved (T-HT: -0.09±0.03s, $p<0.001$; RBP-HT: -0.19±0.04s, $p<0.001$), with the RBP-HT group demonstrating a significantly larger improvement ($p<0.01$) (Table 2).

3.3. Hurdle Clearance Efficiency Score (HCES)

The analysis of the HCES also showed a significant main effect for Time ($F(1, 30)=412.8$, $p<0.001$, $\eta p^2=0.932$) and a significant Group x Time interaction ($F(1, 30)=89.5$, $p<0.001$, $\eta p^2=0.749$). Post-hoc analysis indicated significant within-group improvements for both T-HT (+8.1±1.8 points, $p<0.001$) and RBP-HT (+15.3±2.1 points, $p<0.001$). The improvement in the RBP-HT group was significantly greater than in the T-HT group ($p<0.001$) (Table 2).

Table 2. Pre- and Post-Intervention Performance Data (Mean±SD)

Measure	Group	Pre-Test	Post-Test	Change (Post-Pre)	p-value (Within-Group)	Effect Size (d)
110m Hurdle Time (s)	T-HT	16.55±0.48	15.83±0.41	-0.72±0.18	< 0.001	1.63
	RBP-HT	16.45±0.42	15.24±0.38	-1.21±0.15	< 0.001	2.97
Flying 30m Time (s)	T-HT	3.15±0.11	3.06±0.10	-0.09±0.03	< 0.001	0.86
	RBP-HT	3.13±0.09	2.94±0.08	-0.19±0.04	< 0.001	2.28
HCES (Points)	T-HT	72.5±5.1	80.6±4.8	+8.1±1.8	< 0.001	1.63
	RBP-HT	73.8±4.7	89.1±3.9	+15.3±2.1	< 0.001	3.60

Note: p-value for between-group difference in Change scores was<0.001 for all three measures.

4. Discussion

The primary finding of this 12-week randomized controlled trial is that the Rhythm-Based and Plyometric Hurdle Training (RBP-HT) program elicited significantly greater improvements in 110m hurdle performance, flat sprint speed, and technical hurdling efficiency compared to the Traditional Hurdle Training (T-HT) program among male students at Wuhan Sports University. This supports our initial hypothesis and underscores the value of integrating advanced perceptual and plyometric elements into hurdle training [3].

The superior improvement in the 110m hurdle time in the RBP-HT group (-1.21s vs. -0.72s) is of substantial practical significance for a developing athlete. This enhancement is likely the product of a synergistic effect from the combined improvements in flat speed (Flying 30m) and technical efficiency (HCES). The RBP-HT group's greater gain in flying 30m speed (-0.19s vs. -0.09s) suggests that the contextual plyometrics and resisted/assisted running drills had a more potent transfer to pure sprinting ability. The bounding and hopping exercises directly develop the leg stiffness and reactive strength essential for high-velocity sprinting, which constitutes a large portion of the hurdle race [4].

The most pronounced difference between groups was observed in the Hurdle Clearance Efficiency Score (HCES). The RBP-HT group's improvement was nearly double that of the T-HT group. This can be directly attributed to the specific nature of the RBP-HT intervention. The rhythm discrimination drills (variable spacing) forced athletes to constantly adapt their stride pattern and take-off point, preventing the development of a rigid, "one-pattern-fits-all" technique. This likely enhanced their spatial awareness and ability to make micro-adjustments during a race, leading to more consistent and optimal take-off and landing distances (Bridgett & Linthorne, 2006).

Furthermore, the extensive use of hurdle-specific plyometrics (bounding, speed hops) provided a powerful stimulus for improving the explosive and reactive components of the clearance cycle. By performing these exercises over hurdles, the athletes trained their neuromuscular system to produce force rapidly and efficiently in the exact movement pattern required for the event. This contrasts with traditional drills, which may focus more on the form of the lead and trail leg in a less dynamic context. The result was a more economical clearance, characterized by a shorter flight time and lower clearance height, as reflected in the HCES. A lower, faster clearance minimizes the parabolic flight path, thereby reducing air time and allowing for a quicker return to sprinting [5].

The use of assisted and resisted hurdling in the RBP-HT group also provided unique benefits. Assisted hurdling allowed athletes to experience and "feel" a faster rhythm than they were normally capable of, potentially enhancing motor learning and neural drive. Resisted hurdling, on the other hand, strengthened the powerful extension required at take-off, contributing to greater push-off force and potentially longer landing distances, which can set up a better subsequent sprint step.

From a pedagogical perspective, the RBP-HT approach may have also increased motivation and engagement by introducing more variety and game-like challenges into the training sessions, compared to the more repetitive nature of the T-HT program.

5. Conclusion

This study provides robust experimental evidence that a 12-week training intervention emphasizing rhythm discrimination, contextual plyometrics, and assisted/resisted hurdling is superior to a traditional technique-focused training program for improving the 110-meter hurdle performance of sports university students. The RBP-HT program led to significantly greater gains in overall race time, underlying sprint speed, and the technical efficiency of the hurdle clearance action.

5.1. Practical Applications

Coaches working with developing hurdlers are encouraged to move beyond repetitive technical drills and integrate the following into their training regimens. Variable hurdle spacing: It can cultivate the adaptive rhythm and perception ability of athletes. Specific hurdle-enhancing training: For instance, consecutive jumps and crossing hurdles can build the reaction strength of athletes. Assisting and resisting hurdles: By manipulating the training environment, athletes' high-speed rhythm and strength can be developed.

5.2. Limitations and Future Research

This study has several limitations. First, it only included male athletes from a single sports university, which may limit the generalizability of the findings to female hurdlers or other populations. Second, the biomechanical analysis was limited to a single hurdle; future research could employ motion capture systems to analyze multiple hurdles and inter-hurdle steps. Third, the long-term retention of these performance benefits was not assessed. Future studies should investigate the effects of these training modalities on female athletes, younger age groups, and elite-level performers over longer periods.

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