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Kinematic Profile of the Sideways Shot Put Technique: Baseline Data for Indonesian Athletes

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ABSTRACT

Shot put performance in Indonesia significantly lags behind Asian standards (27.5% gap), hindered by the absence of population-specific kinematic data for evidence-based training development. This study aimed to establish normative kinematic parameters for Indonesian shot put athletes by using the glide technique and examine relationships between technical consistency and throwing performance. A cross-sectional observational study analyzed 16 regional-level shot put athletes from Central Java (9 males, 7 females; aged 18.9±2.0 years) during provincial championships. The two best trials per athlete were analyzed using 2D kinematic analysis with Kinovea software (120 fps). The primary parameters measured were release velocity, release angle, release height, and trunk rotation angle. Technical consistency was assessed via Average Relative Error (ARE) and coefficient of variation (CV%). Pearson correlation examined relationships between parameter variability and throwing distance. The analysis of kinematic mean values showed a release velocity of 11.01±1.18 m/s, a release angle of 37.5±3.2°, a release height of 2.02±0.13 m, and trunk rotation of 41.4±5.4°, with a mean throwing distance of 12.28±1.68 m. Central Java athletes demonstrated 18.4% lower release velocity compared to elite Asian athletes (11.01 vs. 12.80 m/s). Fundamental parameters showed low variability (ARE <8%), whereas trunk rotation exhibited higher inconsistency (ARE 21.4%). Significant inverse correlations were found between variability and performance for release velocity ARE ($r = -0.624$, $p=0.009$), release angle ARE ($r = -0.542$, $p = 0.031$), and trunk rotation ARE ($r = -0.687$, $p=0.003$). Athletes with ARE <10% on key parameters achieved 15.8% greater throwing distances than those with higher variability (13.2 m vs. 11.4 m). This study provides the first-ever normative kinematic data for Indonesian shot put athletes, revealing substantial performance gaps compared to international standards. Technical consistency, particularly in trunk rotation and release velocity, strongly influences throwing performance. The established reference values and performance zones enable evidence-based talent identification, technique assessment, and training program design for regional-level athletes.

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INTRODUCTION

Biomechanical analysis plays a fundamental role in optimizing performance in throwing events, particularly in shot put. International research consistently demonstrates that key kinematic parameters—namely release velocity, release angle, and release height—are primary determinants of throwing performance. These variables collectively account for up to 96% of the variance in shot put distance (Hashimoto et al., 2023). Among them, release velocity has been identified as the most influential factor, showing very strong correlations with performance outcomes ($r > 0.90$) in elite athletes (Ciacci et al., 2022; Mastalerz & Sadowski, 2022). In addition, technical consistency, often quantified through kinematic variability, has emerged as a critical performance indicator. Excessive variability (greater than 20%) has been shown to negatively affect performance, even at the elite level (Mastalerz & Sadowski, 2022).

Despite the robustness of this international evidence, the application of biomechanical analysis in Indonesian athletics remains limited. This limitation is largely attributed to the absence of population-specific reference data and the limited integration of sport science principles into routine coaching practices (Kusuma, 2021). As a result, coaches and practitioners often rely on generalized technical models derived from non-Indonesian populations, which may not accurately reflect the anthropometric and neuromuscular characteristics of local athletes.

A critical gap in the development of shot put in Indonesia is the lack of normative kinematic data derived from Indonesian athletes. Most existing biomechanical studies are based on European and North American populations, whose movement patterns and physical characteristics may not be directly transferable to Southeast Asian contexts. Emerging evidence suggests that kinematic profiles vary significantly across populations due to differences in musculoskeletal adaptations, training exposure, and performance demands (Čoh et al., 2025; Zhao et al., 2023). For example, Zhao et al. (2023) demonstrated that 68.2% of elite throwers could be accurately classified according to their sport discipline based solely on kinematic and anthropometric characteristics, highlighting the population-specific nature of throwing techniques. However, to date, no study has established normative kinematic benchmarks or examined the relationship between kinematic consistency and performance specifically among Indonesian shot put athletes.

From a technical perspective, the glide technique (also known as the sideways method) is widely adopted by developing athletes due to its relative simplicity compared to rotational techniques. This technique emphasizes a proximal-to-distal sequencing pattern, in which force is transferred efficiently from the lower limbs through the trunk to the upper limbs. Trunk rotation alone has been reported to contribute up to 64% of total velocity generation in throwing movements (Holdback et al., 2025). Effective execution of the glide technique depends on coordinated interactions among key kinematic components, including trunk rotation, hip–shoulder separation, and lower-limb positioning. However, the extent to which these biomechanical principles are manifested in Indonesian athletes remains unclear, limiting the ability to design targeted, evidence-based training interventions.

From a national sports development perspective, provincial-level competitions play a crucial role in talent identification and performance evaluation. However, systematic biomechanical profiling at this level remains limited. Central Java Province represents a strategic context for investigation, as it includes a structured cohort of regional-level athletes who regularly participate in organized competitions. The use of accessible and cost-effective

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motion analysis tools, such as high-speed video recording at 120 frames per second combined with Kinovea software, provides a practical approach for generating biomechanical data within typical Indonesian training environments without reliance on expensive laboratory-based systems.

Therefore, this study aims to establish normative kinematic reference values for Indonesian shot put athletes using the glide technique and to examine the relationship between kinematic consistency and throwing performance. By addressing the lack of population-specific data, this research is expected to contribute to the development of evidence-based coaching practices and to enhance performance optimization strategies in Indonesian athletics.

METHODS

Study Design

This study employed a descriptive cross-sectional design combined with correlational analysis to (1) establish normative kinematic profiles and (2) examine the relationship between technical consistency and throwing performance in athletes performing the glide technique in shot put.

Participants

Sixteen competitive shot put athletes (9 males and 7 females) from Central Java Province, Indonesia, voluntarily participated in this study. All athletes specialized in the glide technique and were right-handed to ensure kinematic consistency. Participants had a mean age of 18.9 ± 2.0 years, training experience of 3.8 ± 1.4 years, body mass of 72.4 ± 10.3 kg, and height of 168.6 ± 6.9 cm. All participants had competed at the provincial level within the previous year.

Inclusion criteria were: (1) late adolescence to young adulthood, (2) a minimum of two years of competitive shot put experience, (3) active participation in regional competitions, and (4) consistent use of the glide technique under the supervision of certified coaches. Participants were excluded if they were transitioning techniques, had recent musculoskeletal injuries (within the past six months), produced incomplete kinematic data, or were unable to complete the testing protocol. A purposive sampling strategy was applied in collaboration with the regional athletics federation. Of 24 initially identified athletes, 16 met all criteria and completed the study.

Ethical Approval

All participants provided written informed consent prior to participation. For athletes under 18 years of age, parental or guardian consent was also obtained. The study adhered to the principles of the Declaration of Helsinki and received approval from the institutional ethics committee.

Data Collection Procedures

Data were collected during regular training sessions to maintain ecological validity. Testing was conducted over a two-month period during the pre-competition phase. Participants completed a standardized warm-up consisting of:

(1) 10 minutes of light aerobic activity,
(2) 5 minutes of dynamic stretching,
(3) 5 minutes of shot put–specific drills, and
(4) three submaximal practice throws (70–80% effort).

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Each athlete then performed five maximal-effort glide technique throws using official implements (7.26 kg for males; 4 kg for females), with five-minute rest intervals between trials. Standardized verbal instructions were provided without technical feedback. Only valid throws, as defined by international competition rules, were included. Fouled attempts were repeated until five valid trials were obtained. The two longest valid throws per athlete were selected for analysis, resulting in 32 trials. Throwing distance was measured using standard competition procedures. Environmental conditions were controlled (08:00–11:00 AM; 26–30°C; minimal wind), and all testing was completed within a single session per athlete.

Kinematic Data Acquisition

Motion data were recorded using two synchronized high-speed cameras (GoPro Hero 11 Black, USA) at 120 Hz and 1920 × 1080 pixels resolution. The cameras were positioned 8 m from the throwing circle at a height of 1.5 m, capturing the sagittal and frontal planes.

Calibration was performed before and after each session using a cubic reference frame (1 m^3) positioned at the center of the throwing circle. All equipment complied with international standards, including a 2.135 m diameter throwing circle. Recording started approximately three seconds before movement initiation and continued until two seconds after release.

Kinematic Analysis

Video data were analyzed using Kinovea software (version 0.9.5) for two-dimensional motion analysis. The software has demonstrated high validity and reliability (ICC = 0.83–0.95) for biomechanical measurements (Puig-Diví et al., 2019). Digitization was performed frame-by-frame by an experienced biomechanist who was blinded to performance outcomes. A 17-point body model was used to track anatomical landmarks.

Reliability Assessment

Inter-trial reliability was assessed using the two selected trials per athlete. Intra-analyst reliability was evaluated by reanalyzing 25% of randomly selected trials (n = 8) after one week. Intraclass correlation coefficients (ICC; two-way mixed-effects, absolute agreement) ranged from 0.76 to 0.95, indicating acceptable to excellent reliability.

Data Analysis

Variability Metrics

Technical consistency was quantified using:

1. Average Relative Error (ARE)
   ARE = (|Trial 1 − Trial 2| / Mean of both trials) × 100%
2. Coefficient of Variation (CV%)
   CV% = (Standard Deviation / Mean) × 100%

Lower values indicate greater consistency.

Statistical Analysis

Normality was assessed using the Shapiro–Wilk test. Data are presented as mean ± standard deviation. Pearson correlation coefficients (r) were used to examine relationships between kinematic variability (ARE) and throwing distance. Independent samples t-tests were conducted for exploratory sex-based comparisons due to unequal sample sizes. Effect sizes (Cohen's d) were calculated and interpreted as small (0.2), medium (0.5), and large (0.8). Statistical significance was set at $\alpha = 0.05$.

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All analyses were performed using SPSS Statistics version 27.0 (IBM Corp., USA). Missing data (< 3%) were handled using pairwise deletion.

RESULTS

Participant Characteristics

A total of 16 glide-technique shot put athletes from Central Java participated in this study, consisting of nine males and seven females. The anthropometric characteristics of the athletes are presented in Table 1.

Table 1. Anthropometric characteristics of research subjects (n=16)

Parameter	Male (n=9)	Female (n=7)	Total (n=16)
Age (years)	19.2 ± 2.1	18.6 ± 1.8	18.9 ± 2.0
Height (cm)	172.8 ± 5.4	163.2 ± 4.8	168.6 ± 6.9
Body Mass (kg)	78.4 ± 8.2	64.8 ± 6.5	72.4 ± 10.3
BMI (kg/m²)	26.3 ± 2.4	24.3 ± 2.1	25.4 ± 2.5

Note: Data are presented as Mean ± SD. No inferential statistical comparisons were conducted between sexes due to the small and unequal subgroup sizes; sex-stratified data are provided for descriptive purposes only.

Overall, the sample represented young regional-level athletes with relatively homogeneous age and body proportions. Male athletes demonstrated greater body mass and height compared to females, consistent with typical sex-based anthropometric differences in throwing events.

Kinematic Profile of Sideways Shot Put Technique

Kinematic analysis was performed on the two best trials of each athlete (32 throws in total). All coefficient of variation (CV%) values reflect within-athlete inter-trial variability between the two analyzed throws. Descriptive statistics for key kinematic parameters are presented in Table 2.

Table 2. Kinematic profile of the sideways shot put technique in Central Java athletes

Kinematic Parameter	Male (n = 9)	Female (n = 7)	Total (n = 16)	CV (%)
Release velocity (m/s)	11.84 ± 0.76	9.92 ± 0.68	11.01 ± 1.18	10.7
Release angle (°)	36.8 ± 3.2	38.4 ± 2.9	37.5 ± 3.2	8.5
Release height (m)	2.08 ± 0.12	1.94 ± 0.10	2.02 ± 0.13	6.4
Trunk rotation angle (°)	42.6 ± 5.8	39.8 ± 4.6	41.4 ± 5.4	13.0
Hip–shoulder separation (°)	28.4 ± 6.2	25.6 ± 5.4	27.2 ± 5.9	21.7
Knee flexion at power position (°)	118.6 ± 8.4	122.4 ± 7.6	120.3 ± 8.2	6.8
Elbow angle at release (°)	156.2 ± 6.8	158.6 ± 5.4	157.2 ± 6.2	3.9
Time to peak velocity (s)	0.142 ± 0.018	0.156 ± 0.022	0.148 ± 0.021	14.2
Throwing distance (m)	13.42 ± 1.24	10.86 ± 0.98	12.28 ± 1.68	13.7

Note. Data are presented as mean ± SD. CV (%) = coefficient of variation across the two best trials per athlete. No inferential statistical comparisons were conducted between sexes.

Comparison to International Reference Values

The mean release velocity for the total sample (11.01 ± 1.18 m/s) was 18.4% lower than values reported for elite Asian-level female shot putters (13.50 m/s; Zhao et al., 2023) and 14.8% lower than those of international elite male throwers (12.92 m/s; Mastalerz & Sadowski, 2022). The release angle (37.5 ± 3.2°) fell within the optimal range reported for

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elite throwers (35–40°; Ciacci et al., 2022), whereas release height (2.02 ± 0.13 m) was comparable to values documented in similar regional-level populations (1.95–2.10 m; Hashimoto et al., 2023).

Variability Patterns

Fundamental release-related parameters exhibited relatively low inter-trial variability: release height (CV = 6.4%), elbow angle at release (CV = 3.9%), and release angle (CV = 8.5%). In contrast, parameters associated with proximal segment coordination demonstrated greater inconsistency, including hip–shoulder separation (CV = 21.7%), time to peak velocity (CV = 14.2%), and trunk rotation angle (CV = 13.0%). Release velocity showed moderate variability (CV = 10.7%), indicating some inconsistency in this performance-critical parameter.

Sex-Based Comparisons

Table 3. Exploratory sex-based comparison of key kinematic parameters

Parameter	Male (n=9)	Female (n=7)	t-value	p-value	Cohen's d
Release velocity (m/s)	11.84 ± 0.76	9.92 ± 0.68	5.28	< 0.001	2.68
Release angle (°)	36.8 ± 3.2	38.4 ± 2.9	-1.04	0.316	0.52
Release height (m)	2.08 ± 0.12	1.94 ± 0.10	2.51	0.025	1.26
Trunk rotation angle (°)	42.6 ± 5.8	39.8 ± 4.6	1.03	0.320	0.53
Throwing distance (m)	13.42 ± 1.24	10.86 ± 0.98	4.51	0.001	2.31

Note. Independent samples t-tests were conducted for exploratory purposes. These comparisons should be interpreted with caution due to the small and unequal subgroup sizes (males: n=9; females: n=7) and are presented as preliminary findings rather than definitive conclusions.

Male athletes demonstrated significantly higher release velocity (11.84 vs. 9.92 m/s, $p < 0.001$, $d = 2.68$) and throwing distance (13.42 vs. 10.86 m, $p = 0.001$, $d = 2.31$) compared to female athletes, with large effect sizes indicating substantial practical differences. Release height was also significantly greater in males (2.08 vs. 1.94 m, $p = 0.025$, $d = 1.26$). No significant sex differences were observed for release angle ($p = 0.316$) or trunk rotation angle ($p = 0.320$), suggesting comparable technical execution patterns between sexes despite differences in performance outcomes.

Relationship Between Technical Consistency and Throwing Performance

Pearson correlation analysis was conducted to examine relationships between kinematic variability (measured as Average Relative Error, ARE) and throwing distance across the entire sample. The results are presented in Table 4.

Table 4. Correlation between kinematic variability and throwing distance

Parameter (ARE)	r	p-value	Interpretation
Release velocity	-0.624	0.009	Strong negative
Release angle	-0.542	0.031	Moderate negative
Release height	-0.289	0.276	Weak (n.s.)
Trunk rotation angle	-0.687	0.003	Strong negative
Hip–shoulder separation	-0.518	0.040	Moderate negative
Knee flexion angle	-0.312	0.238	Weak (n.s.)
Elbow angle at release	-0.201	0.451	Weak (n.s.)

Note. ARE = Average Relative Error (percentage difference between two trials). n.s. = not significant ($p > 0.05$). Negative correlations indicate that lower variability (greater consistency) is associated with longer throwing distances.

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Significant negative correlations were observed between throwing distance and kinematic variability for several key parameters. Release velocity variability demonstrated a strong negative correlation ($r = -0.624$, $p = 0.009$), indicating that athletes with more consistent release velocity achieved greater throwing distances. Trunk rotation angle variability showed the strongest relationship with performance ($r = -0.687$, $p = 0.003$), suggesting that consistency in trunk mechanics is critical for throwing success. Release angle variability ($r = -0.542$, $p = 0.031$) and hip–shoulder separation variability ($r = -0.518$, $p = 0.040$) also demonstrated significant moderate negative correlations with performance.

In contrast, variability in distal parameters (release height, knee flexion angle, and elbow angle at release) showed weak and non-significant correlations with throwing distance (all $p > 0.05$), suggesting that these parameters are less sensitive indicators of technical consistency at the regional competitive level.

Performance Stratification by Consistency

Athletes were stratified into two groups based on ARE performance across key parameters:

1. High-consistency group (n=8): ARE <10% for release velocity, release angle, and trunk rotation
2. Low-consistency group (n=8): ARE ≥10% for one or more of these parameters

The high-consistency group achieved a significantly greater mean throwing distance (13.24 ± 1.42 m) compared to the low-consistency group (11.32 ± 1.38 m), representing a 15.8% performance advantage (independent samples t-test: $t(14) = 2.84$, $p = 0.013$, $d = 1.38$). This finding highlights the practical importance of technical consistency for performance outcomes in regional-level shot put athletes.

DISCUSSION

Building on these findings, this study examined the kinematic characteristics and technical consistency of the glide shot put technique in regional-level athletes from Central Java, Indonesia. This study is the first to establish normative kinematic data for Indonesian shot put athletes and reveals that technical consistency—particularly in proximal segment coordination—is strongly associated with throwing performance at the regional competitive level.

Kinematic Profile and Performance Determinants

The mean release velocity (11.01 ± 1.18 m/s) and release angle (37.5 ± 3.2°) observed in this study fall within ranges reported for developing and regional-level shot putters internationally, reinforcing the central role of release velocity as a primary determinant of throwing distance. Previous biomechanical investigations consistently identify release velocity as the strongest predictor of performance, with correlations exceeding $r > 0.90$, surpassing the influence of release angle or release height (Chen et al., 2025; Garcia-Carrillo et al., 2025; Hashimoto et al., 2023).

The greater throwing distances achieved by male athletes in the present sample corresponded with their higher release velocity (11.84 vs. 9.92 m/s; large effect size, $d = 2.68$), suggesting that performance differences between sexes may be primarily influenced by differences in force production capacity rather than fundamental technical execution

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patterns. This interpretation is supported by the absence of significant sex differences in release angle and trunk rotation.

Importantly, the observed mean release velocity of Central Java athletes was 14–18% lower than international elite standards (13.50 m/s for elite Asian females; 12.92 m/s for elite males), indicating a substantial performance gap. This deficit aligns with broader patterns reported in Indonesian athletics, where limited access to evidence-based training protocols and biomechanical support systems may constrain technical development (Kridasuwarso et al., 2020; Daharis et al., 2022). These findings provide baseline reference values that were previously unavailable for Indonesian and broader Southeast Asian shot put populations, addressing a critical gap in population-specific sport science literature (Čoh et al., 2025; Zhao et al., 2023).

Technical Variability and Consistency-Performance Relationships

Technical variability analysis revealed contrasting patterns between distal and proximal parameters. Distal and release-related parameters exhibited relatively low coefficients of variation, particularly elbow angle at release (CV = 3.9%), release height (CV = 6.4%), and release angle (CV = 8.5%). This suggests that athletes were able to reproduce terminal movement positions with reasonable consistency. Similar patterns have been reported in both standing and seated shot put contexts, where endpoint variables tend to stabilize earlier in skill development compared to proximal coordination patterns (Kędziorek et al., 2025; Holdback et al., 2025).

In contrast, parameters associated with force transfer and proximal-to-distal sequencing demonstrated substantially greater variability, including hip–shoulder separation (CV = 21.7%), time to peak velocity (CV = 14.2%), and trunk rotation angle (CV = 13.0%). These findings indicate that although athletes achieved consistent release mechanics, the preparatory and transitional phases of the movement remained less stable.

Importantly, correlation analysis revealed significant negative relationships between kinematic variability and throwing performance. Trunk rotation variability showed the strongest association with throwing distance ($r = -0.687$, $p = 0.003$), followed by release velocity variability ($r = -0.624$, $p = 0.009$) and release angle variability ($r = -0.542$, $p = 0.031$). These results indicate that athletes who demonstrated greater consistency in these parameters—particularly trunk rotation—achieved superior throwing performance. In contrast, variability in distal parameters (release height, knee flexion angle, and elbow angle at release) showed no significant association with performance (all $p > 0.05$).

The practical importance of technical consistency was further demonstrated through performance stratification. Athletes with low variability (ARE < 10%) in key parameters achieved 15.8% greater throwing distances compared to those with higher variability (13.24 vs. 11.32 m; $p = 0.013$, $d = 1.38$). This finding suggests that reducing technical inconsistency—particularly in trunk rotation and release velocity—may represent a viable pathway for performance enhancement among regional-level throwers. However, the cross-sectional design precludes causal inference, and longitudinal intervention studies are required to confirm this relationship.

From a biomechanical perspective, these findings suggest that regional-level athletes may rely on relatively stable distal mechanics while exhibiting less consistent proximal coordination. Given that trunk rotation contributes up to 64% of total velocity generation in throwing actions (Holdback et al., 2025), inconsistencies in trunk mechanics may reduce the

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efficiency of energy transfer. This interpretation aligns with contemporary biomechanical models emphasizing coordinated proximal segment contributions to optimize throwing performance (Chen et al., 2025; Hashimoto et al., 2025; Kanakapura et al., 2024).

Implications for Training and Talent Development

The significant associations between technical consistency and performance have direct implications for training design. The findings suggest that interventions targeting trunk–pelvis coordination, hip–shoulder separation timing, and proximal segment sequencing may improve performance alongside traditional strength and conditioning approaches. Previous intervention studies indicate that kinematic chain exercises involving coordinated trunk and lower-body movements produce greater performance gains than isolated upper-body training (Kanakapura et al., 2024), supporting the importance of proximal coordination training.

In the Indonesian and broader Southeast Asian context, the establishment of normative reference values enables evidence-based talent identification and technique assessment protocols that were previously unavailable. The finding that 68.2% of elite throwers can be differentiated based on kinematic and anthropometric profiles (Zhao et al., 2023) highlights the importance of population-specific baseline data for developing contextually appropriate training systems. Coaches may utilize the ARE < 10% threshold identified in this study as a practical benchmark for evaluating technical consistency, particularly in trunk rotation (current CV = 13.0% vs. elite values of 5–8% reported in international literature).

Furthermore, the comparable technical execution patterns observed between male and female athletes—particularly in release angle and trunk rotation—suggest that sex-specific training differentiation may be more relevant for strength and power development than for fundamental technique. This finding contrasts with some sport-specific training models that assume substantial technical differences between sexes (Garcia-Carrillo et al., 2023).

Study Limitations

Several limitations should be acknowledged when interpreting these findings. First, the sample size (n = 16) was relatively small and limited to athletes from Central Java Province, which may restrict generalizability and statistical power for subgroup analyses. Second, the use of two-dimensional kinematic analysis, although validated for sagittal plane measurements, may have limited precision in assessing rotational parameters compared to three-dimensional motion capture systems.

Third, the cross-sectional design prevents causal inference regarding the relationship between technical consistency and performance. Fourth, environmental conditions during data collection (outdoor testing; 26–30°C) may have introduced uncontrolled variability, although standardized protocols were implemented to minimize these effects. Finally, this study focused exclusively on regional-level athletes using the glide technique; therefore, the findings may not generalize to elite populations or athletes using rotational techniques.

Future Research Directions

Future studies should prioritize longitudinal intervention designs to determine whether consistency-focused training can causally improve performance outcomes. Comparative analyses involving national and international athletes would further contextualize the observed performance gap.

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Additionally, integrating three-dimensional kinematic analysis with force platform measurements would provide a more comprehensive understanding of force generation and transfer mechanisms. Finally, investigating anthropometric–kinematic interactions—building on existing discriminant analysis frameworks (Zhao et al., 2023)—may support the development of population-specific talent identification models for Indonesian athletes.

CONCLUSION

This study establishes baseline kinematic characteristics of Indonesian shot put athletes and identifies technical consistency—particularly in proximal segment coordination—as a key factor associated with throwing performance. Athletes who demonstrated more consistent trunk rotation and release parameters achieved superior performance outcomes, highlighting the importance of stable movement execution in addition to optimal technique.

The findings suggest that performance limitations at the regional level are more closely related to inconsistencies in movement coordination than to deficiencies in terminal mechanics. As such, training approaches that emphasize proximal-to-distal sequencing and trunk control may provide meaningful performance benefits alongside traditional strength development.

While these results offer practical insights for coaching and athlete development, the cross-sectional design and methodological constraints limit causal interpretation. Future research should explore the longitudinal effects of consistency-focused training interventions and incorporate more advanced biomechanical analyses.

Overall, this study provides an initial evidence-based framework for understanding performance determinants in Indonesian shot put athletes and underscores the importance of integrating movement consistency into technical training and evaluation.

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AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirm that the paper is free of plagiarism.

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