



## Measurement Reliability and the Effectiveness of Shooting Training in Beginner Basketball Athletes Based on ARISEBA-Tech

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### Abstract

**Background.** Basketball shooting performance is influenced by multiple physical, technical, and perceptual-motor factors, leading recent research to emphasize the role of technology-assisted training and objective performance measurement. However, standardized shooting assessment instruments remain largely dependent on manual observation and are rarely integrated with systems capable of supporting structured motor learning process control.

**Objectives.** This pilot study aimed to evaluate the measurement reliability of ARISEBA-Tech and to examine the effectiveness of an eight-week technology-assisted shooting training program in beginner basketball athletes.

**Materials and Methods.** A quasi-experimental pretest–posttest design, combined with test–retest reliability analysis, was employed. Twenty-nine beginner university basketball players completed standardized shooting assessments (BJSAT, SST, and CBST), which were recorded automatically using ARISEBA-Tech. Reliability was assessed using intraclass correlation coefficients (ICC) and coefficients of variation (CV). Performance changes were analyzed using paired-sample t-tests or Wilcoxon signed-rank tests, with effect sizes calculated using Cohen's *d*.

**Results.** Most shooting performance variables demonstrated good to very good reliability (ICC > 0.80). Time-based variables showed lower variability compared with accuracy-related measures. Following the intervention, significant improvements were observed in shooting accuracy and execution efficiency ( $p < 0.05$ ), with moderate to large effect sizes ( $d = 0.38–1.33$ ).

**Conclusions.** ARISEBA-Tech provides reliable automated performance measurement and shows potential to support the structured regulation of motor learning processes in beginner shooting training. As a pilot study, the findings provide preliminary empirical evidence rather than generalizable conclusions, indicating the need for larger controlled studies and the integration of movement technique analysis.

**Keywords:** basketball, training, shooting performance, sensor-based assessment.

### Introduction

Basketball is a dynamic team sport that requires repeated high-intensity actions, including shooting under time pressure and defensive constraints (Cao et al., 2024; Bourdas et al., 2024). Team success is largely determined by shooting effectiveness, particularly in critical game situations such as the final moments of a match (Cabarkapa et al., 2023), making shooting performance a key indicator of

basketball proficiency. Shooting performance emerges from complex interactions among individual characteristics, task demands, and game environmental conditions (Amaro et al., 2024), and is influenced by physical condition (Brini et al., 2025), shooting angle and velocity (Chen, 2024), as well as the coordination of motor control, visual perception, and psychological stability, especially under conditions of fatigue and pressure (Chmiel & Buryta, 2025; Court Gold et al., 2025). In addition, lower-limb strength, dynamic balance, and postural control contribute significantly to shooting accuracy and consistency (Ji, 2020; Boddington et al., 2019; Ntasis, 2019; Rösch et al., 2022; Zhang, 2025). In practice,

shooting occurs in multiple forms and contexts, including free throws, jump shots, lay-ups, and three-point shots, and can be performed under unguarded or guarded conditions (Cabarkapa et al., 2023; Chen, 2024; Court Gold et al., 2025).

This complexity indicates that shooting is a skill that requires precise training methods and objective measurement approaches. In recent years, digital technologies have increasingly been used to support basketball shooting training, enabling objective data collection, real-time performance monitoring, automated regulation of practice repetitions, optimization of execution timing, and more accurate feedback compared with traditional observational methods (Zhao et al., 2023; Weng et al., 2025; Svoboda et al., 2024). Previous studies have shown that technology-assisted training can enhance training efficiency, regulate practice repetitions, optimize execution timing, and improve systematic monitoring of shooting outcomes (Boonsom & Bungmark, 2024; Xue, 2024; Bourdas et al., 2024).

From a motor learning perspective, basketball shooting represents a complex perceptual-motor skill that requires not only movement execution but also regulation of the learning process during practice. Motor performance depends on the flexibility of cognitive control systems, efficient allocation of attentional resources, and information processing capacity that support adaptive motor behavior (Gentili et al., 2015; Gutiérrez-Capote et al., 2023). Effective skill acquisition is strongly influenced by structured control of practice variables, including repetition frequency, feedback timing, and monitoring of motor adaptation (Choo et al., 2024; Williams & Hodges, 2023; Ren et al., 2025). These mechanisms are essential for facilitating motor memory formation, improving movement consistency, and supporting long-term retention of shooting skills, particularly among beginner athletes who require guided and adaptive training environments (Kubicek et al., 2023; Dehais et al., 2020).

In terms of performance assessment, several standardized basketball shooting instruments such as the Basketball Jump Shooting Accuracy Test (BJSAT) (Boddington et al., 2019; Boddington et al., 2020), Basketball Long-Range Accuracy Performance Index (BALPAI) (Rösch et al., 2022), Standardized Shooting Task (SST) (Daub et al., 2023), and Combined Basketball Skill Test (CBST) (Conte et al., 2019) have demonstrated good validity and reliability. However, these instruments still rely heavily on manual observation, which introduces subjectivity and limits implementation efficiency and measurement consistency.

More importantly, this situation reflects a conceptual gap between the intended role of technology in training namely supporting structured regulation of the motor learning process and current measurement practices that remain focused primarily on evaluating final performance outcomes. Existing instruments are not integrated with technological systems capable of adaptively controlling practice variables, monitoring skill development in real time, and providing continuous feedback during training. Thus, although technology has been used to record performance outcomes, its integration with mechanisms for motor learning process control remains limited.

To address this gap, the present study develops and evaluates ARISEBA-Tech, a sensor-based system designed to integrate automatic recording of shooting accuracy, monitoring of execution time, and real-time regulation of training repetitions. The system is intended not only as a training aid but also as

an automatic recording system that can be integrated with standardized shooting instruments to enhance measurement objectivity while supporting more effective control of the motor learning process. Given that ARISEBA-Tech is still in an early stage of development, this research is positioned as a pilot study aimed at providing preliminary empirical evidence regarding measurement reliability and training effectiveness, rather than producing broad generalizations.



Fig. 1. System ARISEBA-Tech

Therefore, this study is expected to contribute to bridging the gap between shooting performance measurement and motor learning process control in technology-assisted basketball training. This investigation is particularly relevant given the limited evidence on technology-based basketball training for junior and beginner athletes, who require structured training and appropriate assessment to support long-term development (Slimi et al., 2025; Huang & Chen, 2023; Conte et al., 2019; Wang, 2024). Accordingly, this study aims to: (1) evaluate the reliability of basketball shooting performance measurements produced by the ARISEBA-Tech system when implementing standardized shooting instruments (BJSAT, SST, and CBST); and (2) examine the effectiveness of integrating ARISEBA-Tech into a structured training program to improve the shooting accuracy of beginner basketball athletes.

## Materials and Methods

### Research Design

This study is a pilot study, using a quasi-experimental design with a pretest–posttest approach, accompanied by an evaluation of measurement reliability.

### Participants

A total of 29 beginner university basketball players (age 18–22 years; mean height  $177.3 \pm 4.1$  cm; mean body mass  $67.5 \pm 5.2$  kg) with less than one year of formal training experience participated in this study. The sample size was determined based on pilot study conventions rather than formal statistical power calculations. In pilot intervention research, a sample size of approximately 20–30 participants is generally considered adequate to evaluate feasibility, estimate preliminary effect sizes, and assess measurement reliability prior to conducting larger confirmatory trials. Therefore, the inclusion of 29 participants was considered sufficient to provide preliminary empirical evidence regarding the reliability and effectiveness of ARISEBA-Tech,

while acknowledging that the findings are exploratory and not intended for population generalization.

Inclusion criteria were: (1) no musculoskeletal injury within the past six months and (2) regular participation in basic basketball training activities. Participants with medical conditions limiting the ability to perform high-intensity physical activity were excluded. All participants provided informed consent, and the study was approved by the institutional ethics committee and conducted in accordance with the Declaration of Helsinki.

### *Instruments*

#### *Basketball Jump Shooting Accuracy Test (BJSAT)*

BJSAT is used to assess jump shot accuracy from eight predetermined shooting spots, consisting of four spots at two-point range and four spots at three-point range. Each participant completed four trials. Each shot was scored as follows: score 0: the ball does not touch the rim, score 1: the ball touches the rim, score 2: the ball touches the rim and goes in, score 3: the ball goes into the basket without touching the rim. The total score of each trial was divided by the number of shooting spots (8), then the values from the four trials were summed to obtain the final BJSAT score.

#### *Standardized Shooting Task (SST)*

SST is used to assess shooting accuracy under several conditions, which include: (1) free throw shooting, consisting of 60 attempts without a time limit; (2) two-point spot-to-spot shooting from seven shooting spots with a time limit of 4 minutes; and (3) three-point spot-to-spot shooting from seven shooting spots with a time limit of 4 minutes. Performance variables analyzed include the number of made shots for each type of shooting (free throw, two-point, and three-point).

#### *Combined Basketball Skill Test (CBST)*

CBST is used to assess integrated basketball skills through 12 trials, consisting of: 4 jump shot trials, 4 lay-up trials, and 4 reverse lay-up trials, with the execution order made uncertain (randomized manually or using a system). After the randomization mechanism is applied, a "Visual Stimulus" appears on the prepared screen. The visual stimulus is described as the appearance of a dark orange ball image for jump shots, blue for lay-ups, and red for reverse lay-ups. The performance variables measured include shooting accuracy and task completion time. Thus, the best value for shooting accuracy is 12 points. The completion time reflects the duration of the execution of the activity sequence, including passing, dribbling, changes of direction, and shooting execution. The best time from each type of shooting is used as the performance score for completion time.

#### *ARISEBA-Tech System*

ARISEBA-Tech is a sensor-based basketball shooting performance recording system; this system is capable of automatically recording shooting outcomes, calculating the

number of repetitions, and regulating and displaying the duration of shooting execution. In this study, ARISEBA-Tech is positioned as an automatic recording system integrated with the implementation of standardized shooting instruments. In this study, ARISEBA-Tech can be fully integrated with the implementation of BJSAT and SST. In CBST, the function of ARISEBA-Tech is used to record shooting accuracy and completion time, while the manual penalty system in the original CBST protocol (e.g., wrong ball selection: +4 seconds, wrong hand lay-up: +2 s, loss of ball control: +5 s, moving before stimulus: +3 s) is omitted, due to limitations in the functionality of ARISEBA-Tech.

### *Procedures*

#### *Measurement Reliability Test*

Evaluation of the consistency of ARISEBA-Tech automatic recording was conducted through reliability testing using the test-retest method. Participants performed the same series of shooting tests on two separate occasions with a one-week interval to minimize fatigue effects and short-term learning.

#### *Training Intervention*

The first test in the reliability test (test-retest) was designated as the initial measurement result (pre-test), then all participants followed a structured shooting training program for eight weeks, with a frequency of 3–4 sessions per week and a duration of approximately 60 minutes per session. This duration and frequency were selected because they have been reported to be adequate to facilitate physiological adaptations, improvements in movement coordination, and enhancements in motor control related to basketball shooting performance (Xue, 2024; Zacharakis et al., 2020; Gong et al., 2025). All training sessions were conducted under the supervision of licensed coaches to ensure adherence to the training protocol and participant safety. Post-test measurements were conducted after all participants completed the training program.

ARISEBA-Tech enables the regulation of repetitions, rest intervals, training duration, and the number of sets through a web-based platform, either manually or automatically. The automatic mode allows adaptive adjustment of training variables based on objective data obtained during standardized tests integrated with ARISEBA-Tech. The system also features automatic determination of training volume based on the maximum repetition principle (50–100%), aimed at maintaining an optimal balance between training load and gradual performance improvement. All parameters are displayed in real time on a digital scoreboard, providing immediate visual feedback.

#### *Data Analysis*

The reliability of shooting performance recording using ARISEBA-Tech was analyzed using the Intraclass Correlation Coefficient (ICC) to assess the consistency of measurement results over time, as well as the Coefficient of Variation (CV) to assess the relative stability of the data, complemented by descriptive statistics in the form of mean

**Table 1.** Test–Retest Reliability of ARISEBA-Tech–Based Shooting Measurements

Instrument / Variable	Mean ± SD Test 1	Mean ± SD Test 2	Cronbach's α	ICC (3,1)	95% CI	Interpretation
BJSAT (Accuracy)	3.77 ± 0.74	4.04 ± 0.76	0.984	0.911	0.147 – 0.977	Very good
CBST Lay-up (Accuracy)	2.52 ± 0.95	2.31 ± 0.89	0.923	0.840	0.670 – 0.924	Good
CBST Lay-up (Time)	23.02 ± 0.95	22.57 ± 0.93	0.987	0.871	–0.029 – 0.970	Good
CBST Reverse Lay-up (Accuracy)	2.07 ± 0.92	1.86 ± 0.83	0.942	0.869	0.701 – 0.941	Good
CBST Reverse Lay-up (Time)	23.60 ± 0.84	23.19 ± 0.80	0.982	0.858	–0.026 – 0.965	Good
CBST Jump Shot 2 Point (Accuracy)	2.79 ± 0.98	2.69 ± 1.17	0.910	0.836	0.683 – 0.919	Good
CBST Jump Shot 2 Point (Time)	22.45 ± 1.15	22.00 ± 1.11	0.990	0.908	0.009 – 0.979	Very good
SST Free Throw	26.66 ± 5.53	23.59 ± 8.97	0.697	0.501	0.178 – 0.728	Moderate
SST Jump Shot 2 Point	3.83 ± 1.49	4.07 ± 1.75	0.981	0.955	0.887 – 0.980	Very good
SST Jump Shot 3 Point	2.83 ± 1.44	3.03 ± 1.57	0.968	0.929	0.843 – 0.967	Very good

and standard deviation. Analysis of training effectiveness began with descriptive statistics (mean and standard deviation), normality testing using the Shapiro–Wilk test ( $p > 0.05$ ). Differences between pretest and posttest were analyzed using a paired-sample t-test ( $p < 0.05$ ) if the data were normally distributed, or the Wilcoxon Signed-Rank Test ( $p < 0.05$ ) if normality was not met. Analysis of intervention effects used Cohen's d (small: 0.20, medium: 0.50, and large: 0.80).

## Results

### Measurement Reliability Test

Table 1 shows that most shooting instruments have ICC values in the good to very good categories ( $ICC > 0.80$ ), which indicates consistency of measurement results over time. The instruments with the highest ICC values are the SST two-point jump shot and SST three-point jump shot, while the lowest ICC value is found in the SST free throw, which indicates moderate consistency.

Table 2 presents the coefficient of variation (CV) as an indicator of the level of performance variation among participants. Time-based instruments in the CBST show low CV values ( $<10\%$ ), both at pre-test and post-test, which indicates performance stability among participants. In contrast, accuracy score-based instruments show higher CV values, particularly in shooting tasks with higher levels of difficulty, which reflects heterogeneity of shooting ability among beginner athletes.

### Effectiveness of ARISEBA-Tech

Table 3 shows that descriptively all shooting variables experienced performance improvements at post-test, indicated by increases in mean accuracy scores (BJSAT, SST, and CBST) and decreases in task completion time for time-based CBST variables. The range of minimum and maximum values indicates that performance improvements occurred relatively consistently among most participants, without prominent extreme outliers.

The results of the Shapiro–Wilk test in Table 4 show that most variables are normally distributed ( $p > 0.05$ ), particularly BJSAT scores, all SST subtests, and time-based

**Table 2.** Coefficient of Variation (CV) of Shooting Measurement Results

Instrument / Variable	Test	Mean	SD	CV (%)	Level of Variation
BJSAT	Test 1	3.77	0.74	19.6	Moderate
	Test 2	4.04	0.76	18.9	
CBST Lay-up (Outcome)	Test 1	2.52	0.95	37.7	High
	Test 2	2.31	0.89	38.5	
CBST Lay-up (Time)	Test 1	23.02	0.95	4.1	Low
	Test 2	22.57	0.93	4.1	
CBST Reverse Lay-up (Outcome)	Test 1	2.07	0.92	44.4	High
	Test 2	1.86	0.83	44.6	
CBST Reverse Lay-up (Time)	Test 1	23.60	0.84	3.6	Low
	Test 2	23.19	0.80	3.4	
CBST Jump Shot 2 Point (Outcome)	Test 1	2.79	0.98	35.1	High
	Test 2	2.69	1.17	43.5	
CBST Jump Shot 2 Point (Time)	Test 1	22.45	1.15	5.1	Low
	Test 2	22.00	1.11	5.0	
SST Free Throw	Test 1	26.66	5.53	20.7	Moderate–High
	Test 2	23.59	8.97	38.0	
SST Jump Shot 3 Point	Test 1	2.83	1.44	50.9	Very high
	Test 2	3.03	1.57	51.8	
SST Jump Shot 2 Point	Test 1	3.83	1.49	38.9	High
	Test 2	4.07	1.75	43.0	

CBST variables. In contrast, score-based CBST variables (lay-up, reverse lay-up, and two-point jump shot) show non-normal distributions ( $p < 0.05$ ). Based on these findings, analysis of pre-test and post-test differences was conducted using paired-sample t-tests for normally distributed data and Wilcoxon signed-rank tests for non-normally distributed data, in accordance with principles of inferential statistical analysis.

The results of the paired-sample t-test in Table 5 show that there are significant differences between pre-test and post-test scores for all normally distributed variables ( $p < 0.05$ ). These findings indicate that the use of ARISEBA-

**Table 3.** Descriptive statistics of pre-test and post-test shooting scores

Variable	Pre-test (Mean ± SD)	Post-test (Mean ± SD)
BJSAT	3.77 ± 0.74	4.64 ± 0.93
SST – Free Throw	26.66 ± 5.53	29.24 ± 7.57
SST – Jump Shot 3 Point	2.83 ± 1.44	3.45 ± 1.70
SST – Jump Shot 2 Point	3.83 ± 1.49	4.76 ± 1.41
CBST – Lay-up (score)	4.62 ± 0.73	5.38 ± 0.56
CBST – Reverse Lay-up (score)	4.10 ± 0.77	5.03 ± 0.60
CBST – Jump Shot 2 Point (score)	4.34 ± 0.61	4.79 ± 0.63
CBST – Lay-up (time, seconds)	23.02 ± 0.95	22.46 ± 0.94
CBST – Reverse Lay-up (time, seconds)	23.60 ± 0.84	23.09 ± 0.80
CBST – Jump Shot 2 Point (time, seconds)	22.45 ± 1.15	21.91 ± 1.08

**Table 4.** Results of the normality test

Variable	Shapiro-Wilk (W)	Sig. (p)	Decision
BJSAT	0.962	0.412	Normal
SST – Free Throw	0.955	0.276	Normal
SST – Jump Shot 3 Point	0.967	0.521	Normal
SST – Jump Shot 2 Point	0.971	0.603	Normal
CBST – Lay-up (score)	0.903	0.018	Not normal
CBST – Reverse Lay-up (score)	0.892	0.011	Not normal
CBST – Jump Shot 2 Point (score)	0.918	0.032	Not normal
CBST – Lay-up (time)	0.969	0.548	Normal
CBST – Reverse Lay-up (time)	0.973	0.621	Normal
CBST – Jump Shot 2 Point (time)	0.961	0.401	Normal

**Table 5.** Results of the paired-sample t-test

Variable	Mean Difference	t	df	Sig. (p)
BJSAT	-0.87	-15.74	28	< 0.001
SST – Free Throw	-2.58	-3.02	28	0.005
SST – Jump Shot 3 Point	-0.62	-5.38	28	< 0.001
SST – Jump Shot 2 Point	-0.93	-7.70	28	< 0.001
CBST – Lay-up (time)	0.56	10.05	28	< 0.001
CBST – Reverse Lay-up (time)	0.51	11.36	28	< 0.001
CBST – Jump Shot 2 Point (time)	0.54	9.13	28	< 0.001

Tech significantly increases shooting accuracy while also accelerating task completion time in beginner basketball athletes.

The Wilcoxon signed-rank test in Table 6 shows significant increases in scores for all score-based CBST variables ( $p < 0.05$ ). These results confirm that the integration of ARISEBA-Tech not only improves movement efficiency, but also has a positive impact on the quality and accuracy of shooting execution in dynamic situations.

**Table 6.** Results of the Wilcoxon signed-rank test

CBST Variable	Z	P (2-tailed)	Decision
CBST – Lay-up (score)	-3.606	< 0.001	Significant
CBST – Reverse Lay-up (score)	-4.185	< 0.001	Significant
CBST – Jump Shot 2 Point (score)	-2.121	< 0.001	Significant

The analysis of effect size in Table 7 shows that the ARISEBA-Tech-based training intervention provides moderate to large effects on improving shooting performance in beginner basketball athletes. The largest effects are found in score-based CBST variables, particularly lay-up and reverse lay-up skills ( $d > 1.00$ ), which reflect improvements in the quality of shooting execution under dynamic conditions. Meanwhile, SST and time-based CBST variables show moderate effects, indicating that the intervention not only improves accuracy, but also movement efficiency and task completion speed.

**Table 7.** Effect size (Cohen's d) of the ARISEBA-Tech intervention

Variable	Cohen's d	Effect Category
BJSAT	1.05	Large
SST – Free Throw	0.38	Small-Moderate
SST – Jump Shot 3 Point	0.40	Moderate
SST – Jump Shot 2 Point	0.65	Moderate
CBST – Lay-up (score)	1.18	Large
CBST – Reverse Lay-up (score)	1.33	Large
CBST – Jump Shot 2 Point (score)	0.73	Moderate
CBST – Lay-up (time)	0.59	Moderate
CBST – Reverse Lay-up (time)	0.63	Moderate
CBST – Jump Shot 2 Point (time)	0.49	Moderate

## Discussion

This study is a pilot study aimed at evaluating the initial effectiveness of ARISEBA-Tech in improving shooting performance among beginner basketball athletes, as well as the feasibility of integrating standardized basketball shooting instruments into a sensor-based measurement system.

### Measurement Reliability

The reliability analysis demonstrated that most shooting measurements implemented through ARISEBA-Tech

showed good to very good consistency, as indicated by high ICC values. These findings confirm that the system is capable of producing stable and repeatable performance data across repeated measurements, which is essential for longitudinal monitoring in skill training contexts (Hove et al., 2022).

The use of a two-way mixed-effects ICC model with absolute agreement further indicates that ARISEBA-Tech ensures not only consistency in performance ranking among athletes but also equivalence of absolute measurement scores. This is particularly important in training evaluation, where small performance changes must be detected with high precision. The automated recording mechanism of ARISEBA-Tech likely contributed to this stability by minimizing human error and procedural variability commonly associated with manual observation, which is a known advantage of sensor-based performance assessment systems (Schneikart & Mayrhofer, 2022; Li et al., 2025).

Complementary analysis using the coefficient of variation (CV) provided additional insight into performance stability. Low CV values observed in time-based variables suggest homogeneous execution speed among participants, whereas higher CV values in accuracy-related variables reflect expected variability in shooting ability among beginner athletes. Such variability is characteristic of early stages of motor skill acquisition, where performance fluctuations represent functional motor variability associated with exploration and adaptation rather than measurement inconsistency (Vidal & Lacquaniti, 2021; Moreno et al., 2023).

The slightly lower reliability observed in the SST free-throw task may be attributed to the high precision demands of closed-skill performance, which require consistent execution of fixed movement patterns. Small deviations in technique can therefore produce larger score variations compared with more dynamic shooting tasks (Goldschmied et al., 2022). Overall, these findings indicate that integrating standardized shooting instruments with ARISEBA-Tech produces objective, stable, and reliable measurements, supporting its suitability for repeated performance monitoring and evaluation in beginner basketball training contexts.

#### *Effectiveness of ARISEBA-Tech*

The results demonstrated significant improvements across all shooting accuracy and time-based performance variables following the ARISEBA-Tech-based intervention. The consistent direction of change across multiple standardized shooting instruments indicates that the system is capable of producing measurable short-term performance gains in beginner basketball athletes.

These improvements may be partly explained by two key features of ARISEBA-Tech: real-time visual performance feedback and individualized automatic regulation of training repetitions. The visual scoreboard provides augmented knowledge-of-results feedback, which is widely recognized as an important factor in early stages of motor skill acquisition by helping learners interpret performance outcomes and adjust subsequent attempts (Sigrist et al., 2013; Wulf et al., 2010).

In addition, the system's automatic adjustment of training repetitions based on individual performance

capacity likely contributed to more consistent practice exposure among participants. Motor learning theory emphasizes that structured control of practice variables, including practice volume and task difficulty, plays a critical role in facilitating skill acquisition (Magill & Anderson, 2014; Moreno & Ordoño, 2015; Debatin et al., 2023). In this context, ARISEBA-Tech appears to support a more individualized and structured training process compared with conventional repetitive practice.

However, given the pilot nature of this study, these findings should be interpreted as preliminary evidence rather than definitive proof of causal learning mechanisms. The quasi-experimental design, relatively small sample size, and absence of direct measurements of movement technique or retention limit the ability to determine the underlying processes responsible for the observed performance improvements.

Furthermore, because the sample size was determined based on pilot-study conventions rather than formal statistical power calculations, the results should be interpreted as exploratory and primarily intended to estimate preliminary effect sizes for future confirmatory research.

Overall, the results suggest that ARISEBA-Tech has practical potential as a technology-assisted training system capable of supporting short-term improvements in shooting performance while providing structured and objective performance monitoring in beginner basketball training contexts.

#### *Contribution, practical implications, limitations, and future research*

This study provides an important contribution by demonstrating the feasibility of integrating standardized basketball shooting assessment instruments with a sensor-based training and measurement system. Unlike conventional approaches that primarily focus on outcome evaluation, ARISEBA-Tech enables simultaneous performance measurement and structured regulation of practice variables. In this way, the study helps bridge the conceptual gap between performance assessment and motor learning process control in technology-assisted skill training.

From a practical perspective, ARISEBA-Tech offers a structured and objective approach to shooting training for beginner athletes. The system allows coaches to monitor performance in real time, regulate training repetitions based on individual ability, and provide standardized feedback without relying solely on manual observation. These features may help improve training efficiency, consistency of evaluation, and athlete engagement during repetitive skill practice.

Despite these promising findings, several limitations should be acknowledged. First, the study employed a quasi-experimental design without a control group, which limits causal interpretation of training effects. Second, the relatively small sample size restricts generalizability of the findings. Third, the study focused exclusively on performance outcomes without assessing movement technique, learning retention, or cognitive processes underlying motor skill acquisition. Therefore, the results should be interpreted as preliminary evidence within a pilot-study framework.

Therefore, future studies should incorporate larger samples with formal statistical power analysis to validate

the magnitude and stability of the observed effects. Future studies should employ randomized controlled designs with larger samples to establish stronger causal evidence regarding the effectiveness of ARISEBA-Tech-based training. Further research is also needed to integrate movement technique analysis, examine long-term retention effects, and investigate how technology-assisted feedback influences motor learning processes across different stages of skill development.

## Conclusions

The findings of this pilot study indicate that ARISEBA-Tech demonstrates good to very good reliability in automatically recording basketball shooting performance and is suitable for repeated performance monitoring in beginner athletes. The eight-week training intervention incorporating real-time visual feedback and automatic regulation of training repetitions was associated with significant improvements in shooting accuracy and execution efficiency, with moderate to large effect sizes.

These results should be interpreted as preliminary empirical evidence rather than definitive proof of causal learning mechanisms. Nevertheless, the findings suggest that integrating standardized shooting assessment instruments with sensor-based technology may support more structured regulation of motor learning processes during training. Therefore, this study contributes to bridging the gap between performance measurement and motor learning process control in technology-assisted basketball training.

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## Conflict of interest

No Conflicts of interest.

## AI Transparency Statement

The authors declare that no artificial intelligence (AI) tools were used to generate data, perform analyses, or produce the scientific content of this manuscript. AI-assisted language tools were used only for grammar refinement and language editing, and all final content remains the responsibility of the authors.

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## Надійність вимірювань і ефективність тренування кидків у баскетболістів-початківців на основі ARISEBA-Tech

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 10 с., 7 табл., 1 рис., 44 джерела.

**Обґрунтування.** Результативність кидків у баскетболі визначається множинними фізичними, технічними та перцептивно-моторними чинниками, що зумовлює акцент сучасних досліджень на ролі технологічно підтримуваного тренування та об'єктивного вимірювання результатів. Водночас стандартизовані інструменти оцінювання кидків значною мірою залишаються залежними від ручного спостереження та рідко інтегруються з системами, здатними забезпечити структуроване керування процесом навчання рухів.

**Мета.** Це пілотне дослідження мало на меті оцінити надійність вимірювань ARISEBA-Tech та дослідити ефективність восьмижневої програми тренування кидків із використанням технологічної підтримки у баскетболістів-початківців.

**Матеріали і методи.** Було застосовано квазіекспериментальний дизайн «до-після», поєднаний з аналізом надійності за схемою «тест-ретест». Двадцять дев'ять студентів-баскетболістів початкового рівня виконали стандартизовані тести кидків (BJSAT, SST та CBST), які автоматично реєструвалися за допомогою ARISEBA-Tech. Надійність оцінювали за допомогою внутрішньокласових коефіцієнтів кореляції (ICC) та коефіцієнтів варіації (CV). Зміни показників аналізували за допомогою парного t-тесту або критерію знакових рангів Вілкоксона з розрахунком розмірів ефекту за Коеном (*d*).

**Результати.** Більшість показників результативності кидків продемонстрували добру та дуже добру надійність (ICC > 0,80). Часові показники характеризувалися нижчою варіабельністю порівняно з показниками точності. Після втручання зафіксовано статистично значущі покращення точності кидків та ефективності їх виконання ( $p < 0,05$ ) із помірними та великими розмірами ефекту ( $d = 0,38-1,33$ ).

**Висновки.** ARISEBA-Tech забезпечує надійне автоматизоване вимірювання результатів і демонструє потенціал для підтримки структурованого керування процесами навчання рухів у підготовці кидків у початківців. Як пілотне дослідження, отримані результати мають попередній емпіричний характер і не можуть бути узагальнені, що зумовлює необхідність подальших досліджень із більшими вибірками та контрольованими дизайнами, а також інтеграції аналізу техніки рухів.

**Ключові слова:** баскетбол, тренування, результативність кидків, сенсорно-орієнтоване оцінювання.

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