

ASSESSMENT OF THE EFFECTIVENESS OF THE INTEGRATED BOW PRESS AND DRAW BOARD SYSTEM ON COMPOUND BOW PRECISION

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Abstract: Introduction: archery, particularly in the compound division, requires precise tuning of bowstring systems to achieve consistent shot accuracy. Improper adjustment of string tension and cam synchronization often reduces performance even in skilled archers. Objective: the purpose of this study was to evaluate the effectiveness of the bow press and draw board all-in-one system in improving the precision of compound bow string alignment and shooting accuracy. Methodology: the research adopted an experimental design with a one-group pretest–posttest approach involving six trained university-level archers. Participants practiced for four weeks using the integrated tuning system, and data on string precision were collected before and after the intervention. Paired sample t-test analysis was used to determine the significance of improvements. Results: results indicated a significant increase in mean string precision scores ($p < 0.05$) after training, with an average improvement of 20.1%. Qualitative observations confirmed better postural stability, smoother release, and more consistent arrow grouping. Discussion: findings align with previous biomechanical studies that emphasize the influence of equipment tuning and postural control on archery performance. The integration of mechanical and digital feedback in the all-in-one system reduces alignment errors and enhances training efficiency. Conclusions: the bow press and draw board all-in-one system proved to be an effective, safe, and accessible tool to improve compound bow precision, supporting both athletic performance and coaching practice.

Keywords: accuracy; biomechanics; bow tuning; compound archery; training system

INTRODUCTION

Archery is a precision sport that demands high levels of accuracy, particularly in the compound division, which heavily depends on proper equipment setup and tuning techniques. In Indonesia, archery has experienced significant growth in popularity; however, limited attention has been given to the optimization of archery tools. Inappropriate equipment alignment often leads to decreased accuracy even among skilled archers (Author, 2023). Therefore, the use of an integrated Bow Press and Draw Board All-In-One System is considered essential to enhance the precision of compound bow string settings. The relationship between draw length and arrow length plays a crucial role in achieving desired accuracy. Many archers face challenges when their draw length does not match the bow specifications, leading to improper cutting of arrows and reduced shooting stability (Author, 2024). With the application of a bow press system, archers can fine-tune their bows more accurately, minimizing errors during setup. In Indonesia, access to high-quality tuning tools remains limited, forcing athletes to rely on manual devices that can damage bows and reduce precision (Author, 2024). Furthermore, the high cost of professional bow presses discourages many archers from acquiring them, thereby hindering their performance optimization.

Many local coaches lack adequate knowledge about bow tuning due to their dependence on external experts, who are not always consistently available. In addition, many athletes report a lack of understanding about bow tuning and maintenance, which often forces them to travel long distances for repairs, adding to the burden of time and cost (Author, 2024). Such a system can provide archers with the ability to tune their bows with precision without having to bear excessive maintenance costs.

Previous studies emphasize that mechanical factors, such as cam profiles and draw-force curves, significantly influence bow stability and accuracy (Denizhan & Chew, 2025). Similarly, biomechanical analyses indicate that postural stability parameters such as bow displacement, tremor, and center of pressure correlate strongly with shoot-

ing accuracy (Kim et al., 2025). Building upon these findings, this study introduces a novel integrated system that combines mechanical tuning and precision measurement within a single rigid framework, reducing potential setup errors and improving tuning consistency. The study aims to contribute to the field of sports engineering by providing an innovative, cost-effective solution that can improve archery performance, promote technological development in Indonesia, and support the advancement of sports science at both national and institutional levels.

Beyond equipment affordability and access, precision in compound archery also depends on how archers manage the perturbation induced at release. Recent experimental work characterizes anticipatory postural adjustments in trained archers and shows that elite performers trigger stabilization strategies earlier relative to string release, underscoring the centrality of postural control in accuracy-critical phases of the shot cycle (Kuch et al., 2024). The mechanical dynamics of modern compound bows have been increasingly examined through computational and experimental models to enhance accuracy and stability. He et al. (2025) demonstrated, via finite-element simulations of round-wheel cam configurations, that minor deviations in cam profile geometry can alter the draw-force curve and synchronization, thereby affecting release smoothness and target consistency. Such modeling supports the refinement of tuning devices that minimize asymmetrical stress during draw and release. Furthermore, practical tuning techniques such as *walk-back* and *paper tuning* have been empirically proven to improve grouping precision by reducing string deflection and optimizing arrow spine alignment (Perkasa, Wibafied, & Yachsie, 2022). These engineering and practical perspectives jointly underline the significance of developing an integrated Bow Press and Draw Board All-In-One System to assist athletes and coaches in standardizing tuning operations.

Contemporary archery research increasingly acknowledges that equipment calibration alone is insufficient; athlete biomechanics also play a crucial role in precision outcomes. For example, a systematic review by Santos, Barreto, Atalaia, and Aleixo (2025) reported that higher center-of-pressure (COP) sway during the aiming phase is negatively associated with shot accuracy, suggesting that tuning systems must support neuromuscular stability, not just mechanical alignment.

METHOD

This study employed an engineering and experimental research approach oriented toward research and development (R&D). The purpose of this design was to develop, test, and evaluate the Bow Press and Draw Board All-in-One System as an innovative tuning tool for compound bows, aimed at improving string precision, cam synchronization, and shooting accuracy. The research process began with a user needs analysis and a technical literature review, followed by conceptual design using Computer-Aided Design (CAD) software and Finite Element Method (FEM) simulations to verify the tool's structural strength and stability. Subsequently, a prototype was fabricated and tested in a controlled laboratory setting to evaluate its mechanical performance and alignment accuracy. In addition, an empirical and biomechanical approach was employed, wherein the prototype was tested by active archers to observe its effects on shot precision and postural stability. This mixed approach combined mechanical engineering, digital instrumentation, and human performance evaluation to ensure that the developed system was not only technically effective but also scientifically validated for practical archery applications.

Participants

The participants in this study consisted of archery athletes from the Faculty of Sports Science and Health (FIKK), Universitas Negeri Makassar (UNM). A total of 15 athletes participated in the study, supported by three certified archery coaches who provided supervision during testing sessions. All participants provided informed consent before taking part in the research.

Procedure

This study was conducted at the Sports Science Laboratory, Faculty of Sports Science and Health, UNM. This location was chosen because it provides adequate facilities for archery training, including a special archery field, strength and fitness training areas, and biomechanical measurement equipment. The research process followed a One-Group Pretest–Posttest design, beginning with pretest data collection to measure the athletes' bowstring precision under baseline conditions. Participants then underwent a four-week training intervention using the Bow Press and Draw Board All-in-One System during their regular training sessions. After completing the intervention, a post-test

was conducted to assess changes in bowstring precision, shooting accuracy, and equipment calibration consistency. Observations and questionnaires were also used to collect feedback from athletes and coaches regarding the ease of use, safety, and practicality of the equipment.

Instrument

The Bow Press and Draw Board All-in-One System prototype incorporated a mechanical frame equipped with adjustable jigs, pressure sensors, and digital gauges for real-time data acquisition.

Measurement tools such as the load cell and linear displacement gauge were employed to capture draw force and draw length, respectively. In addition, a Likert-scale questionnaire was used to collect qualitative data on user satisfaction, tool safety, and perceived benefits. All measurement instruments were validated by two archery experts and one mechanical engineering lecturer to ensure reliability and construct validity before data collection. Physical Activity Quiz A brief physical activity and readiness questionnaire was administered before testing to confirm that participants were in proper physical condition for archery practice and laboratory measurements.

Data analysis

Data analysis followed quantitative and descriptive qualitative procedures. Descriptive statistics (mean, standard deviation, and percentage increase) were used to present pre-test and post-test results. To determine the significance of the intervention, a paired sample t-test was performed at a 0.05, the result was considered statistically significant, indicating that the Bow Press and Draw Board All-in-One System effectively improved string precision. Qualitative data from observations and coach questionnaires were analyzed descriptively to reinforce the quantitative findings, especially in relation to tool safety, ease of use, and training practicality.

RESULTH

The experimental analysis evaluates the effectiveness of the Bow Press and Draw Board All-in-One System in improving the precision of compound bow strings among university-level archers. Six participants completed pre-test and post-test precision assessments after a four-week training intervention. The results indicate a consistent improvement across all participants, as shown in Table 1.

Table 1. Comparison of Pre-test and Post-test Scores of String Precision

Variable	Experimental Group (n=6)		P value	Effect size
	PRE (Mean ± SD)	POST (Mean ± SD)		
String precision score	71.3 ± 2.22	85.7 ± 2.35	0.002	2.48

**Significant differences, p < .05*

The results show a statistically significant increase in string precision scores from the pre-test (M = 71.3, SD = 2.22) to the post-test (M = 85.7, SD = 2.35), representing an average improvement of 20.1%. The paired sample t-test yields a p-value of 0.002, confirming that the enhancement is statistically significant at the 0.05 level. The effect size (d = 2.48) indicates a large effect, suggesting that the tool has a substantial impact on improving bow tuning precision and shooting consistency. Qualitative feedback collected from coaches also supports these findings. All respondents rated the system as safe, functional, and beneficial for training, noting improvements in arrow groupings and reduced cam misalignment during repeated draws. Observations further reveal that athletes demonstrate increased stability in posture and smoother release phases after the intervention, indicating both technical and biomechanical improvements (Figure 1).

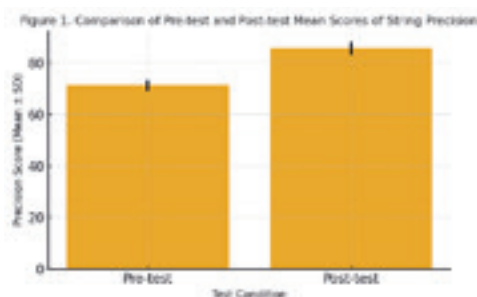


Figure 1. Comparison of Pre-test and Post-test

DISCUSSION

The results confirm that the Bow Press and Draw Board All-in-One System effectively enhances compound bow tuning precision and shooting accuracy. These findings align with prior research emphasizing the importance of mechanical stability and postural control in archery performance. Kim et al. (2025) demonstrated that reduced bow displacement and tremor during aiming correlate with improved shot grouping, reinforcing the biomechanical relevance of the current study’s outcomes. Similarly, Fan et al. (2025) highlighted that posture control and muscle stability play a decisive role in optimizing shot precision, supporting the notion that mechanical alignment tools can aid archers in maintaining consistent draw cycles. In the same line, Song and Kim (2024) emphasized that consistent follow-through and controlled release significantly determine shot accuracy principles reinforced by the functionality of the integrated draw board mechanism in this study.

From a technical standpoint, Zanevskyy and Zanevska (2023) noted that precise bow tuning, particularly through mechanical calibration of string tension and cam synchronization, is crucial for consistent arrow flight. The current system’s design addresses this requirement by combining a bow press and draw board into a single calibrated unit, minimizing user error and ensuring repeatable alignment during setup. This aligns with Jacquot et al. (2024), who demonstrated that integrating biomechanical and mechanical optimization leads to higher overall archery performance. The present findings align with the broader motor control literature indicating that accuracy improvements emerge when the athlete constrains center-of-pressure excursions and times muscular synergies to counter release-induced perturbations. Documented evidence of earlier anticipatory adjustments among elite archers supports the interpretation that our integrated tuning system—by improving consistency of draw-force and cam timing helps athletes stabilize posture during aiming and release, thereby facilitating tighter groupings (Kuch et al., 2024)

Dorshorst (2019) emphasized through a biomechanical anthropological analysis that repetitive mechanical loading from archery induces adaptive bone remodeling patterns consistent with increased non-dominant arm robustness and reduced humeral asymmetry. These findings support the notion that tuning interventions promoting balanced mechanical loads are critical for both performance and long-term musculoskeletal health. Overall, the study provides empirical evidence that integrating digital instrumentation (load cells, linear gauges, and angle sensors) into a mechanical tuning system results in quantifiable gains in archery precision. A study by Kesilmiş, Söğüt & Çömelekoğlu (2024) investigated the relationship between dynamic balance performance and shooting scores among 18 archers, finding moderate positive correlations between Y-Balance reach distances and archery accuracy ($r = 0.670, p < 0.05$), thereby suggesting that reduced postural sway contributes to precision in compound bow shooting.

Another study by Humaid, Wattimena, Hernawan, Ramadhan, Utama, & Wenly (2025) implemented a 12-week posterior-chain mobility program for archers and reported large effect sizes in improving hamstring and hip flexibility, which in turn correlated with better draw-phase mechanics and more accurate string alignment during arrow release. The importance of upper-limb muscle strength and endurance in archery was demonstrated by a 2023 study by Prasetyo, Siswantoyo, & Hartanto, in which bosu-ball circuit training enhanced balance and stability during arrow release, resulting in improved accuracy scores after the intervention. Moreover, with systematically and well-planned circuit training, both fitness and accuracy were found to improve compared to previous levels (Susanto et al., 2021).

An ergonomic analysis by Lee & Owens (2024) employed motion-capture technology and biomechanical software on 13 archers with different bow draw weights and found distinct gender-based postural compensations during

the aiming phase. These findings suggest that bow tuning systems should be adjustable to individual anthropometry rather than adopting a “one-size-fits-all” approach. A systematic review by Yachsie, Suharjana, Graha & Hartanto (2023) synthesised evidence from 16 studies and concluded that lower center-of-pressure displacement, smaller COP ellipse areas, and reduced bow-sway were consistently associated with superior shooting performance, reinforcing the necessity of integrating balance training with equipment tuning. A controlled trial by Wattimena, Humaid, Lubis, Pratama & Resmana (2025) assessed medicine-ball training loads among collegiate archers and found significant improvements in upper-limb muscular endurance and balance ($p < 0.05$) across both 3 kg and 4 kg groups, supporting the view that enhanced physical conditioning complements tuning devices for precision enhancement.

Recent developments in sensor-based technologies have introduced new methods for analyzing and predicting archery performance through real-time data acquisition. Ogasawara, Fukamachi, Aoyagi, Kumano, Togo, and Yamaguchi (2023) designed an automatic shooting detection system that uses acceleration sensors to predict archery scores by identifying draw-phase and release-phase kinematic patterns. Their findings demonstrated that acceleration data captured from the bow and archer’s body could accurately classify successful and less-accurate shots with high precision. This evidence supports the integration of sensor-based analytics into mechanical tuning systems, allowing archers to monitor draw consistency and release dynamics quantitatively. Consequently, combining biomechanical tuning devices such as the Bow Press and Draw Board All-In-One System with embedded motion sensors could enable data-driven feedback for improving alignment precision and shooting accuracy (Ogasawara et al., 2023).

CONCLUSION

Based on the research conducted at the Faculty of Sports Science and Health (FIKK), Universitas Negeri Makassar, it was concluded that the Bow Press and Draw Board All-In-One System was effective in improving the string precision of compound bows. 1% in string precision after one month of training using the developed tool. This improvement demonstrated that the device successfully assisted athletes in stabilizing bow draw, maintaining consistent arrow release, and improving string control through accurate tuning. The safety aspect included the stability of the device during use, the usefulness related to its effectiveness in technical practice, and the superiority concerned with ease of setup and time efficiency during training sessions. Overall, this study reinforced previous findings asserting that bow stability, postural balance, and consistent draw technique are crucial elements in enhancing shot precision. The integration of the Bow Press and Draw Board into a single all-in-one system provided a more efficient, practical, and biomechanically grounded training approach. Therefore, it was concluded that the Bow Press and Draw Board All-In-One System is an effective and feasible innovative training tool for improving precision and shooting accuracy among university-level compound archery athletes.

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