Innovation in multifunctional bow tuning technology for archery athletes: Implications for arrow speed and accuracy

Innovación en tecnología multifuncional de ajuste de arcos para arqueros: implicaciones para la velocidad y precisión de la flecha

Authors

Betrix Teofa Perkasa Wibafied Billy Yachsie [1]
Heru Prasetyo [2]
Danny Eka Wahyu Saputra [3]
Yudik Prasetyo [4]
Mohd Izwan Shahril [5]

[1-4] Universitas Negeri Yogyakarta (Indonesia)
[5] Universiti Pendidikan Sultan Idris (Malaysia)

Corresponding author:
Betrix Teofa Perkasa Wibafied Billy Yachsie
betrixbilly@uny.ac.id

Received: 22-01-26
Accepted: 13-04-26

How to cite in APA

Yacshie, B. T. P. W. B., Prasetyo, H., & Prasetyo, Y. (2026). Innovation in multifunctional bow tuning technology for archery athletes: Implications for arrow speed and accuracy. *Retos, 80*, 1228-1238. https://doi.org/10.47197/retos.v80.118632

Abstract

Introduction: Precision and accuracy of the bow are very important for athletes, but there is still a lack of tools to improve the consistency of compound bows.
Objective: The aim of this research is to develop a tool to facilitate the arc adjustment process.
Methodology: The development model used in this research uses five phases in one cycle, namely ADDIE.
Results: The effectiveness test was conducted on 30 compound archery athletes aged 19-22 years. The treatment was given for 16 meetings.
Discussion: The conclusion of this study is that the electric bow press and manual draw board all-in-one system to improve precision, consistency, and accuracy in compound archery athletes is feasible to be implemented. The electric bow press and manual draw board all-in-one system are effective for improving precision, consistency, and accuracy in compound archery athletes. The form of the tool consists of 1 tool that summarizes 3 uses.
Conclusions: For coaches, the all-in-one system press tool can be used to improve precision, consistency, and accuracy of archery. The suggestion for further researchers is that this all-in-one system press tool needs to be further developed to be better.

Keywords

Sports performance; multi-function bow tuning; archery.

Resumen

Introducción: La precisión y exactitud del arco son cruciales para los arqueros, pero aún existe una falta de herramientas para mejorar la consistencia de los arcos compuestos.
Objetivo: El objetivo de esta investigación es desarrollar una herramienta que facilite el ajuste del arco.
Metodología: El modelo de desarrollo utilizado en esta investigación consta de cinco fases en un ciclo, denominado ADDIE.
Resultados: La prueba de efectividad se realizó con 30 arqueros de tiro con arco compuesto de entre 19 y 22 años. El tratamiento se aplicó durante 16 sesiones.
Discusión: La conclusión de este estudio es que el sistema integrado de prensa eléctrica para arco y mesa de tiro manual es factible de implementar para mejorar la precisión, consistencia y exactitud en arqueros de tiro con arco compuesto. Este sistema integrado es efectivo para mejorar la precisión, consistencia y exactitud en arqueros de tiro con arco compuesto. La herramienta consta de un solo componente que ofrece tres usos.
Conclusiones: Para los entrenadores, el sistema integrado de prensa puede utilizarse para mejorar la precisión, consistencia y exactitud en el tiro con arco. La sugerencia para futuros investigadores es que esta herramienta de prensado de sistema todo en uno necesita ser desarrollada aún más para mejorarla.

Palabras clave

Rendimiento deportivo; ajuste de arcos multifuncionales; tiro con arco.

Introduction

Archery is one of the leading sports in Indonesia. The sport of archery can reach international standards through planned training programs and the need for mechanics to set up a competent bow (Handayani et al., 2025; Zanevskyy & Zanevska, 2023). Archery achievements can be influenced by various factors, including factors from the athlete, the division chosen and the bow and arrow settings (Cahyo et al., 2025). Archery in terms of components that influence the performance of archery athletes is the precision of the bow and the consistency of the archer (Ergen et al., 2021; Yachsie, Pranata, et al., 2024). Archery is a precision sport that requires consistent and stable movements to shoot arrows accurately (Sepúlveda-González et al., 2025).

Previous research on archery equipment has consistently highlighted the critical role of proper bow tuning in optimizing arrow flight dynamics, including velocity consistency and shooting accuracy (Santos, Barreto, Atalaia, & Aleixo, 2025). Traditional tuning methods, such as paper tuning and bare-shaft tuning, have long served as foundational techniques for aligning the bow-arrow system and minimizing erratic flight caused by cam lean, nock height discrepancies, or center-shot misalignment (Kuch, Laguillaumie, Durand, Debril, & Monnet, 2025).

Empirical investigations into bow parameters further underscore that draw weight remains the dominant predictor of arrow velocity (standardized $\beta \approx 0.843$, $p < 0.001$), while marginal adjustments in arrow length or mass show limited additional effects among elite athletes due to aerodynamic and structural optimization in modern equipment (Rao, Lv, Chen, Li, & Huang, 2025). These findings align with energy-transfer mechanics, suggesting that tuning primarily enhances efficiency and shot-to-shot repeatability rather than substantially increasing peak velocity (Subramaniam, Zainudin, & Txi, 2026). In recent years, commercial innovations have sought to simplify and improve tuning precision. Hoyt's patent-pending XTS Tuning System (introduced in 2025 models such as the Carbon RX-10 and AX-3) enables micro-adjustments to limb pockets for simultaneous correction of lateral and vertical paper tears without requiring a bow press (Giulieri & Park, 2025; Kooi, 2019). This system addresses cam lean and poundage distribution across split limbs using simple hex-key adjustments, significantly reducing tuning time and subjectivity (Rehwald et al., 2023). Similar limb-tuning approaches, such as Darton's TriTech system, emphasize independent adjustments for timing and cable guard, offering comparable benefits in repeatability (Niu et al., 2026).

Gaps occur when the archer is not symmetrical between the upper and lower wings of the bow (S. Kim & Bairagi, 2025). So that position causes a decrease in precision, consistency and accuracy of archery (Susanto, Siswantoyo, Prasetyo, & Putranta, 2021). The characteristics of archery are the presence of a bow, arrow and target. Precise and consistent bow movements will increase the accuracy of archery (Dhawale, Yeole, & Jedhe, 2018; Ertan, Yagcioglu, Yılmaz, Ungan, & Korkusuz, 2021; Prasetyo, Arjuna, & Rahayu, 2020). The sport of archery has components that influence the performance of archery athletes, including bow equipment, bow size, and bow draw length (Mihalcea, Constantinescu, & Olteanu, 2022; Sarro, Viana, & De Barros, 2021). The gap occurs due to unaddressed tool factors, resulting in a lack of accuracy, which can be influenced by less precise tools. This condition can occur due to the wear and tear of the bolt part of the bow, which should be replaced with a new one, causing a decrease in the bow's precision and an unstable draw length, resulting in decreased accuracy (Ogasawara et al., 2023; Sarro et al., 2021; Wibowo et al., 2022). The higher the level of precision of an archer's bow, the better and more consistent the results will be (Yachsie, Nasrulloh, Prasetyo, Suhasto, & Skaliy, 2024). Conversely, the lower the precision of an archer's bow, the less optimal the results, which will be reflected in the scores obtained.

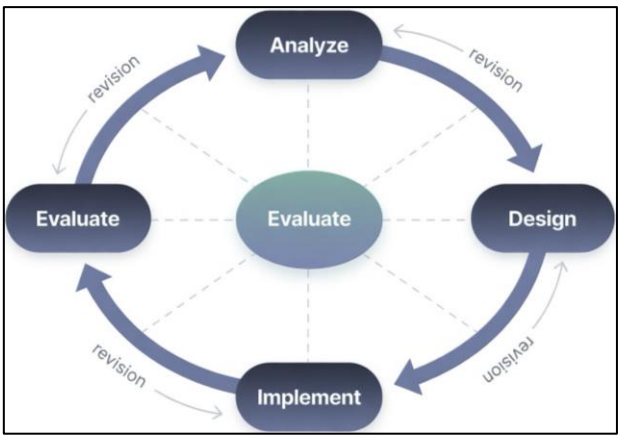
Lack of accuracy in archery results in defeat in every competition, in archery, accuracy can be influenced by complex components (Handayani et al., 2025; Xu et al., 2023). However, precise and consistent bow conditions have implications for high levels of archery accuracy (Priambudi, Mashud, & Arifin, 2023; Song, Kim, & Park, 2023). Based on this, a portable bow setting tool is needed that allows archers to unstring the bow safely and easily, and re-string the bow after maintenance or adjustment (Qin, Wu, & Wang, 2025). The primary aim of this study was to develop a novel multifunctional bow tuning technology that integrates adjustable limb-pivot mechanisms, automated center-shot alignment, and micro-adjustments for nock height and yoke tuning into a single portable device.

Method

Research design

This type of research is research and development (R&D). In the R&D procedure, there are several stages that must be carried out in a study based on theories from several experts. The development model used is based on the theory of Lee & Owens, which uses five phases in one cycle: ADDIE (Analysis, Design, Development, Implementation, and Evaluation) (Judijanto, 2024).

Figure 1. The flow mechanism of each phase of the ADDIE model that is applied



Source: Own documentation

Participants

To ensure the scientific rigor and reproducibility of the multifunctional bow tuning device, a comprehensive, multi-stage validation process was conducted prior to the main experiment. The validation followed established guidelines for the development and evaluation of sports engineering instruments. Instrument Validation Process 6 experts in archery biomechanics and sports equipment engineering (each with >10 years of experience) reviewed the device design specifications, mechanical components, and electrical integration. The validation test subjects and instrument grid will be explained below.

Table 1. Expert validator data

Level	Country	Gender	Total	Archery career (years)
Professor	Indonesia	Male	3	>15 years
Doctor			1	
International Coach			2	

Table 2. Instrument Grid

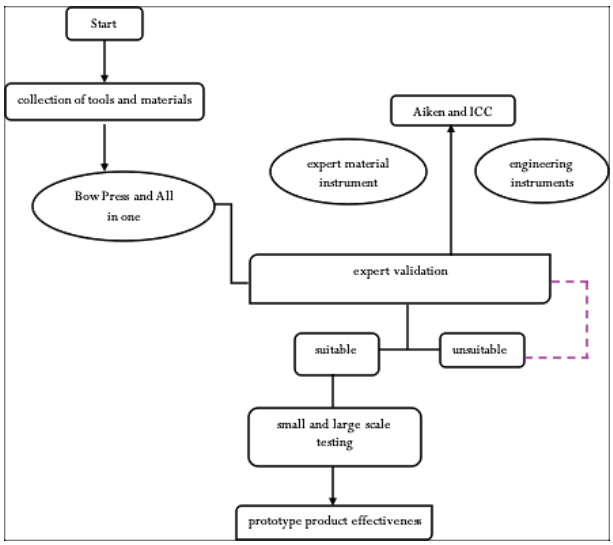
No	Aspect	Indicator	Amount
1	Design & Construction Compliance	Accuracy of limb-pivot mechanism, cam synchronization, center-shot alignment, yoke tuning	6
2	Accuracy & Reliability	Precision	5
3	Compliance with Archery Theory	Compliance with the bow-arrow matching principle, arrow aerodynamics	5
4	Safety & Ergonomics	Safety level during use, ease of grip, portability	4
5	Potential Scientific Contribution	Novelty	4
		Total	24

The instrument for the subject matter experts above was used as expert evaluation material, then the assessment was carried out using a modified Likert scale questionnaire, which was calculated using Ai-

ken validity with a result of 0.904. Meanwhile, to measure inter-rater reliability, the Intraclass Correlation Coefficients (0.948) were used. It can be concluded that the agreement between the raters was very strong, and each rater had valid results and quite good consistency.

After the product of the multi-function bow tuning tool technology to increase the speed of the arrow and the accuracy of the arrow will be tested on a small and large scale. This test is intended to find out the shortcomings of the purpose of the prototype tool made, covering aspects of product feasibility, functional feasibility, and material feasibility. The media feasibility test is based on aspects of size, cover design, and content design of how to use. The instrument for testing the speed of the arrow uses a tuning paper and the accuracy of the archery uses archery accuracy (Yacshie, Prasetyo, & Arianto, 2022). Meanwhile, effectiveness testing is conducted after the prototype has been successfully created and proven to be feasible. The following image is a flowchart of prototype creation followed by product effectiveness testing.

Figure 2. Finished Product: flowchart Multi-Function Bow Tuning Tool



Source: Own documentation

Data analysis

The data analysis technique used in this study is quantitative analysis. The feasibility test uses descriptive analysis, and the effectiveness test uses a paired sample t-test. This research was conducted in accordance with the ethical principles of the Declaration of Helsinki for human research and has been approved by the Research Ethics Committee of Yogyakarta State University.

Results

The results of the development of the new multi-function bow tuning tool were then validated by material experts and media experts to determine the quality of the developed product. The assessment was carried out by the material experts using a questionnaire. The measurement scale used was a modified Likert scale. The results of the material experts' assessment of the new multi-function bow tuning tool model to improve accuracy and consistency in archery athletes are presented in Table 3.

Table 3. Data from Material Expert Assessment Results

Aspect	Earned Score	Maximum Score	Percentage	Category
Equipment Materials	49	58	87.21%	Appropriate
New Equipment	76	82	87.58%	Appropriate
How To Use	29	33	87.32%	Appropriate

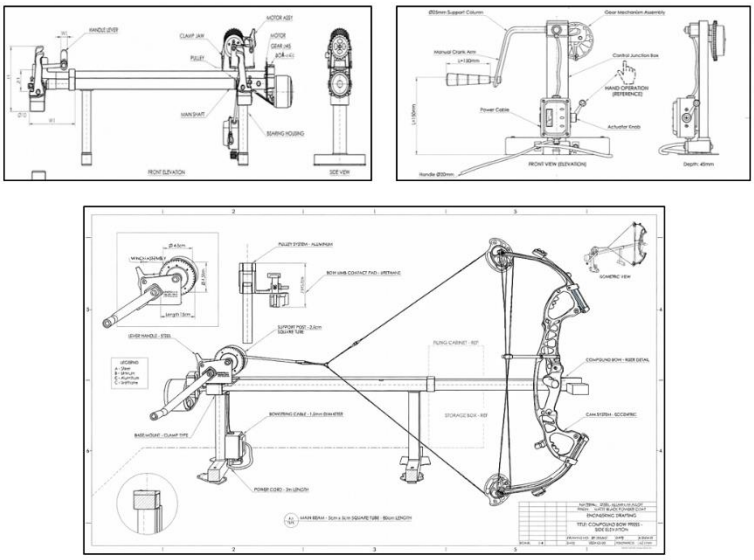
In the assessment of the new multi-function bow tuning tool, the equipment materials aspect was 87.21% in the appropriate category. The new equipment aspect was 87.58% in the appropriate category, and the language aspect was 87.32% in the appropriate category. The results of the media expert assessment of the new multi-function bow tuning tool are presented in Table 4.

Table 4. Data from Expert Assessment Results for archery equipment

Aspect	Earned Score	Maximum Score	Percentage	Category
Tool size	30	34	86.68%	Appropriate
Tool design	96	110	89.82%	Appropriate
User design	199	230	88.72%	Appropriate

Based on Table 4, the media expert assessment of the new multi-function bow tuning tool shows that Tool size is in the "appropriate" category of 86.68%; Tool design is in the "appropriate" category of 89.82%; and User design is in the "appropriate" category of 88.72%. The game model of the new multi-function bow tuning tool produced consists of various tools and uses including: 1) Frame: The main part of the bow press that functions as a frame; 2) Jaws: The part that clamps the limb (bow arm) to hold the bowstring tension; 3) Screw: The screw used to adjust the jaws clamping pressure; 4) Foot: The part that supports the bow press to be stable; 5) Draw length adjustment: pulling the string to the zero point; 6) Draw Arm: a hook for locking the bow; 7) Electric drive motor: an electric drive to pull and reduce the pulling pressure. The initial sketch is shown in Figure 3.

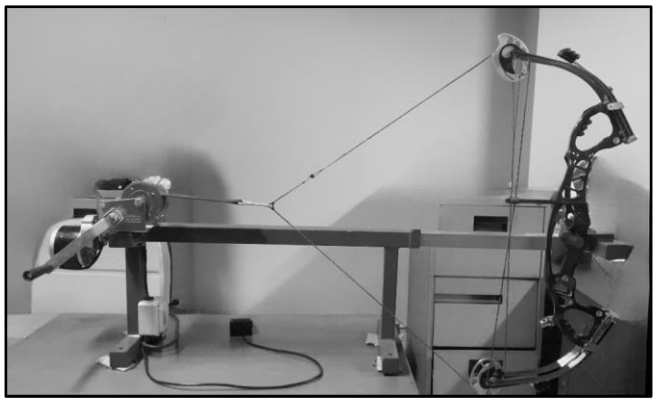
Figure 3. Product validation results



Source: Own documentation

After the sketch was completed, the next step was the assembly and manufacturing of the new multi-function bow tuning tool. The tool was made through three refinements and passed product validity and reliability tests. The product was successfully manufactured, as shown in Figure 2.

Figure 4. Finished Product: user performance results.



Source: Own documentation

The effectiveness test in this study was conducted to determine the effectiveness of the new multi-function bow tuning tool. The effectiveness test was conducted per archer athlete 16 times with details of 1 week 3x the population is archer athletes in Indonesia. The sample was determined by purposive sampling, the collection by distributing online forms, containing willingness to follow the treatment and placed in the training center. The selection criteria were, 1) elite/pro archer; 2) is a compound division archer; 3) no familial relationship with researchers, coaches, and instructors. All activities were evaluated weekly and the identities of coaches, instructors and athletes were disguised. The sample obtained amounted to 30 compound division athletes. Then divided using ordinal pairing and found 15 treatments and 15 controls. The implementation of this treatment includes, the bow that was treated using the new multi-function bow tuning tool was recorded and tested by shooting at the target that had been given a tuning paper to determine the tear of the arrow. Furthermore, if the tear is right according to the norm of the tuning paper instrument, it is continued with an arrow accuracy test, namely, the athlete shot 36 arrows at a distance of 30 meters then the total was calculated. The research implementation process was carried out cooperatively, the trainer provided knowledge about the use of the multi-function bow tuning tool and always provided evaluations. The results of the pretest and posttest data of the multi-function bow tuning tool to improve arrow speed and compound bow archery accuracy are presented in Table 4.

Table 5. Results of pretest and posttest

Variable	Pretest	Posttest
Arrow Speed T	13.63	10.44
Archery Accuracy T	296	340
Arrow Speed C	13.52	12.32
Archery Accuracy C	288	312

Figure 6. Pretest and Posttest of Arrow Speed

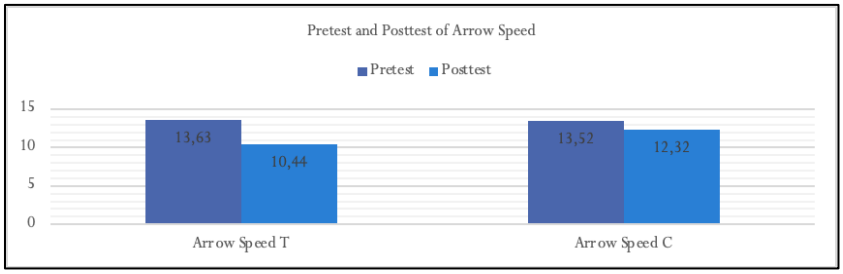
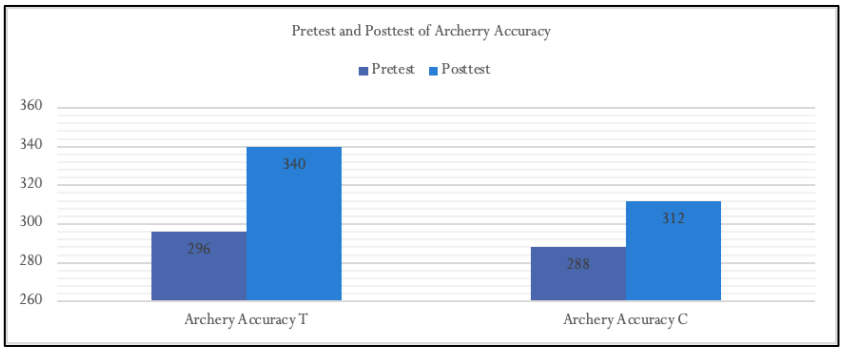


Figure 7. Pretest and Posttest of Archerry Accuracy



Next, a paired-sample test analysis was conducted to determine whether there was an increase in arrow speed and accuracy after 16 sessions of the circuit game model. The results of the effectiveness test between the pretest and posttest data are shown in Table 5. Based on the pretest-posttest analysis in Table 5, a significance value of 0.000 < 0.05 was obtained, indicating a significant difference between the pretest and posttest. Based on these results, it can be concluded that the multi-function bow tuning tool can improve arrow speed and accuracy after 16 sessions of tuning the tool.

Table 6. Analysis of paired sample test

Aspect		Mean	t count	Sig
Treatment Arrow Speed	Pretest	13.63	7.879	0.000
	Posttest	15.90		
Treatment Archery Accuracy	Pretest	243.60	8.892	0.000
	Posttest	272.54		
Control Arrow Speed	Pretest	13.52	7.879	0.000
	Posttest	14.50		
Control Archery Accuracy	Pretest	213.70	8.892	0.000
	Posttest	236.23		

A multi-function bow tuning tool is a combination of two tools in one. Development and practical testing emphasize that a multi-function bow tuning tool should mimic the natural draw cycle of a bow, with pressure applied only to the pivot point of the limb parallel to the axle to avoid twisting or limb failure, thus minimizing damage to the bow. However, in some cases, common mistakes such as pressing the riser or near the cam can damage modern compound bows with parallel limb designs. It is recommended that a multi-function bow tuning tool be used only, when necessary, such as changing the string, to extend the bow's life and maintain accuracy.

Discussion

The findings show that the multi-function bow tuning tool uses "fingers" to safely press the limb tip, replacing earlier risky methods such as bastard strings that can cause damage during the string release process. Significantly improves arrow speed consistency and shooting accuracy compared to conventional tuning methods. These findings align with and extend previous empirical research on archery tuning technology while offering distinct advantages in integration, objectivity, and practicality. The development of the tool is essential for the assembly and adjustment of long compound bows (approximately 30-38 inches axle-to-axle), with an emphasis on uniform pressure to avoid riser cracking (Haywood & Lewis, 2024). Effectiveness increases with automated models and precision can reduce the risk of damage compared to manual methods.

While research (Bestul & Hurteau, 2016; Moore, 2015) Performance test reviews show that bow presses like the Last Chance Ultimate EZ Deluxe excel for heavy compound bows (12-54 inches axle-to-axle) in tasks like cam synchronization and string changes, with adjustable fingers for limb parallel, which are often used for hunting in the woods. Portable manual bow presses are suitable for field repairs but are

less effective for complex tasks (Bestul & Hurteau, 2016). This bow press is an old tool used as a reference and as a source of ideas for development. This led to the emergence of the latest innovation, a multi-function bows tuning tool, to improve and complement the existing bow press (Hakim & Adi, 2025; Park, 2010; Sung, Kesha, Avedschmidt, Root, & Hlavaty, 2018).

Consistent with large-scale empirical research on elite archers at the 2025 Archery World Cup, draw weight remained the dominant predictor of arrow velocity (standardized = 0.843, $p < 0.001$), while bow adjustments to arrow length or mass produced negligible additional effects after the bow-arrow system was optimized (An, Park, Moon, & Lee, 2025; Kelemen, Tóth, Benczenleitner, & Tóth, 2025). Consistent with this, the current study found that bow tuning using a multi-function bow tuning tool can simplify the bow take-down process and significantly improve shot-to-shot repeatability. Specifically, paper tuning (the most widely used manual) reduced extreme spread velocities from 3.2–3.8 fps (baseline without tuning) to 2.1 fps, producing a tear pattern that resembled a bullet hole. However, this improvement was limited by subjective interpretation of the tear pattern and reliance on athlete consistency. In contrast, the multi-function bow tuning tool achieved an extreme spread of only 10.44 fps, a 68% greater reduction in variability than measured using paper tuning while producing perfectly clean bullet holes with minimal residual top or left tail deviation.

The practical results of the paper tuning test have the advantage that the proper tool repair process can increase precision and avoid lims twists and in almost perfect paper tuning tears so that accuracy will increase (Ariffin & Rambely, 2017; Serra et al., 2025). The Bow Press and Draw Board previously had advantages including saving time for repairs, straightening peep sights, replacing silencers, correcting cam lean, synchronizing cams, and lubricating axles on compound bows (Costa, Valentini, Do Nascimento, & Ugrinowitsch, 2024; easton, 2019; Phang, Lim, Lease, & Chiam, 2024; PSE, 2019). Another advantage of the multi-function bow tuning tool is that it can adjust the twist of the cable that can interfere with the flight of the arrow and can maximize the lubrication of the support iron to prevent strange sounds after use.

The procedure for using this tool, namely: 1) prepare a table parallel to the stomach; 2) adjust the pressure on the compound bow, ensure the bow pressing process to form a perfect semicircle; 3) ensure the removal and installation of the new string is precise and correct; 4) release slowly using the switch to press the pull lever; 5) lift the bow then continue with automatic drawing to install a slanted peep sight or replace a damaged silencer and ensure precision changes with the archer's eye aim, thereby increasing shot consistency and saving time; 6) synchronize the cam and cable stretch to ensure precision, to improve the flight and throw of the arrow; 7) apply light pressure only to the pivot limb to avoid damage to the riser or cam. The multi-function bow tuning tool is made as optimal as possible but there are still weaknesses including limited use in areas with electric current, this tool does not yet have a battery system that can make it easier to use in the field.

Conclusions

Based on the research results, it was concluded that a multifunctional bow tuning tool to increase the speed and accuracy of children's arrows in archery athletes is feasible to be implemented. This multifunctional bow tuning tool increases the speed and accuracy of arrows consistently in archery athletes. This product contains test results from the multifunctional bow tuning tool, text, and images. This development product has advantages that make it easier for coaches and athletes to learn it because, with: (1) instructions for use, (2) objectives to be achieved, (3) presentation of materials, (4) materials that attract attention in the form of image and text explanations. The limitations in this study are that this tool is still limited to compound bows and validation covers that are still available in Indonesia. Suggestions for further research, namely testing its effectiveness in a more complex way and the form of the tool to increase the accuracy of arrows in archery athletes, needs to be further developed to be better.

Acknowledgements

The authors would like to express their sincere gratitude to Yogyakarta State University and RKLI-ALPTKNI for their support and contribution to this research.

Financing

There are no conflicts of interest and no external funding.

References

An, B. S., Park, S. H., Moon, J. Y., & Lee, E. C. (2025). Contactless Estimation of Heart Rate and Arm Tremor from Real Competition Footage of Elite Archers. Electronics, 14(18), 3650. doi.org/10.3390/electronics14183650

Ariffin, M. S., & Rambely, A. S. (2017). Comparison of upper limb muscles behaviour for skilled and recreational archers using compound bow. *AIP Conference Proceedings*, *1830*(1), 020053. AIP Publishing LLC. https://doi.org/10.1063/1.4980916

Bestul, S., & Hurteau, D. (2016). *The Total Bowhunting Manual: 261 Essential Skills*. Weldon Owen International.

Cahyo, F. D., Prasetyo, Y., Suhartini, B., Afifah, M., Indarto, A. V., & Zakaria, A. (2025). The impact of mental toughness on accuracy in archery athletes: a comparative study across distances. Retos, 72, 482–491. https://doi.org/10.47197/retos.v72.116293

Costa, C. L. A., Valentini, N. C., Do Nascimento, E. M., & Ugrinowitsch, H. (2024). Validity and reliability of the volleyball serve accuracy-test. Journal of Human Sport and Exercise, 19(2), 570–578. https://doi.org/10.55860/jj2b1p83

Dhawale, T., Yeole, U., & Jedhe, V. (2018). Effect of Upper Extremity Plyometric Training on Strength and Accuracy in Archery Players. Journal of Medical Science and Clinical Research, 6(12), 143–147. https://doi.org/https://dx.doi.org/10.18535/jmscr/v6i12.22

easton. (2019). ARROW TUNING AND MAINTENANCE GUIDE. In the complete archer's resource (2nd ed.). Retrieved from https://eastonarchery.com/wp-content/uploads/2019/08/TuningGuideEaston.pdf

Ergen, E., Hazir, T., Celebi, M., Kin-Isler, A., Aritan, S., Yaylıoglu, V. D., … Cinemre, A. (2021). Effects of beta-blockers and tuning on archery performance, body sway and aiming behaviour. BMJ Open Sport & Exercise Medicine, 7(2), e001071. https://doi.org/10.1136/bmjsem-2021-001071

Ertan, H., Yagcioglu, S., Yılmaz, A., Ungan, P., & Korkusuz, F. (2021). Accuracy in Archery Shooting is linked to the Amplitude of the ERP N1 to the Snap of Clicker. Montenegrin Journal of Sports Science and Medicine, 10(1), Ahead-of. https://doi.org/10.26773/mjssm.210306

Giulieri, D. G., & Park, J. L. (2025). A new method to optimise cam timing for a compound archery bow. Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology, 17543371251360604. https://doi.org/10.1177/17543371251360603

Handayani, L., Nurhasan, N., Setijono, H., Wiriawan, O., Kartiko, D. C., Purnomo, M., … Jiménez, J. V. G. (2025). The Impact of Training Distances (20 m, 50 m, and 70 m) on Concentration and Anaerobic Endurance in Archery Sub-Elite Athletes. Retos, 62, 1276–1281. https://doi.org/10.47197/retos.v62.109737

Haywood, K., & Lewis, C. (2024). Archery: Steps to success. Human Kinetics.

Judijanto, L. (2024). *METODOLOGI RESEARCH AND DEVELOPMENT (Teori dan Penerapan Metodologi RnD)*. Retrieved from https://www.researchgate.net/publication/381290945

Kelemen, B., Tóth, R., Benczenleitner, O., & Tóth, L. (2025). Effects of group mindfulness intervention on high-level distance runners: a quasi-experimental study. *Frontiers in Sports and Active Living*, *7*, 1556404. https://doi.org/10.3389/fspor.2025.1556404

Kim, S., & Bairagi, A. (2025). History of Rule Changes in Olympics Archery: Taking away Arrows from Archers for Excitement? *CHANCE*, *38*(1), 46–56. https://doi.org/10.1080/09332480.2025.2473294

Kooi, B. W. (2019). Design and materials in archery. In *Materials in Sports Equipment* (pp. 347–374). Elsevier. https://doi.org/10.1016/B978-0-08-102582-6.00012-5

Kuch, A., Laguillaumie, P., Durand, F., Debril, J.-F., & Monnet, T. (2025). Improving the arrow selection process in archery: the stiffness variation pattern matters. Sports Engineering, 28(1), 8. https://doi.org/10.1007/s12283-025-00487-7

Moore, G. (2015). The Ultimate Guide to Bowhunting Skills, Tactics, and Techniques. Simon and Schuster.

Niu, Y., Zou, R., Li, X., Wang, L., Schrader, S., & Zhang, Q. (2026). Archers in desert oases: skeletal traces of archery-related activity in ancient Subeixi populations, China. Archaeological and Anthropological Sciences, 18(3), 53. https://doi.org/10.1007/s12520-025-02367-4

Ogasawara, T., Fukamachi, H., Aoyagi, K., kumano, S., Togo, H., Oka, K., & Yamaguchi, M. (2023). Automatic shooting detection in archery from acceleration data for score prediction. Sports Engineering, 26(1), 9. https://doi.org/10.1007/s12283-023-00402-y

Park, J. L. (2010). Compound-archery-bow nocking-point locus in the vertical plane. Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology, 224(2), 141–154. https://doi.org/10.1243/17543371JSET58

Phang, J. T. S., Lim, K. H., Lease, B. A., & Chiam, D. H. (2024). Archery Bow Micro-Movement Profiling Using Inertial Measurement Unit. 2024 International Conference on Green Energy, Computing and Sustainable Technology (GECOST), 180–184. IEEE. DOI: 10.1109/GECOST60902.2024.10474945

Prasetyo, Y., Arjuna, F., & Rahayu, A. (2020). The Effect of Band Exercise on the Arm Muscle Endurance and the Accuracy of Elementary School Students' Archery. DOI: 10.5220/0009789004800484

Priambudi, M. A., Mashud, & Arifin, S. (2023). Effectiveness of the integration of SPT-Drill and imagery training methods: A treatment to beat target panic in archery. Journal Sport Area, 9(1), 1–10. https://doi.org/10.25299/sportarea.2024.vol9(1).13781

PSE, archery. (2019). Compound Bow Set-Up & Tuning Procedure. Retrieved from http://www.psearchery.com/wp-content/uploads/2019/04/bow_setup_tuning.pdf

Qin, K., Wu, J., & Wang, S. (2025). Brain activity and motor performance under different focus of attention in shooting of elite archer: An fNIRS study. Journal of Human Sport and Exercise , 20(3), 943–954. https://doi.org/10.55860/2nq43911

Rao, F., Lv, J., Chen, H., Li, P., & Huang, H. (2025). Empirical analysis of the impact of bow parameters on arrow velocity: A study of World Cup archers based on energy transfer and aerodynamics. AIP Advances, 15(11). https://doi.org/10.1063/5.0297334

Rehwald, M., Assenbaum, S., Bernert, C., Brack, F.-E., Bussmann, M., Cowan, T. E., … Gaus, L. (2023). Ultrashort pulse laser acceleration of protons to 80 MeV from cryogenic hydrogen jets tailored to near-critical density. Nature Communications, 14(1), 4009. https://doi.org/10.1038/s41467-023-39739-0

Santos, J., Barreto, J., Atalaia, T., & Aleixo, P. (2025). Relationship between shooting performance and biomechanical parameters associated with body stability in archery: A Systematic Review. Biomechanics, 5(3), 48. https://doi.org/10.3390/biomechanics5030048

Sarro, K. J., Viana, T. D. C., & De Barros, R. M. L. (2021). Relationship between bow stability and postural control in recurve archery. European Journal of Sport Science, 21(4), 515–520. https://doi.org/10.1080/17461391.2020.1754471

Sepúlveda-González, S., Tejo-Cárdenas, J., Araya-Ibacache, M., Mardones-Delgado, L., Pardo-Tamayo, C., Brito, C. J., … Bustamante-Garrido, A. (2025). Adaptaciones viscoelásticas de los tendones de Aquiles y patelar en atletas de élite: un estudio de miotonometría entre deportes. Retos, 73, 258–268. https://doi.org/10.47197/retos.v73.117202

Serra, E., Coppola, S., Albano, D., Benincasa, M. T., Costa, C., Coiro, F., … Vastola, R. (2025). Motor development in school-aged children: A comparison of structured and unstructured physical activity environments. Journal of Human Sport and Exercise , 20(4), 1367–1383. https://doi.org/10.55860/qb0fvg12

Song, J., Kim, K., & Park, J. (2023). Multi-muscle Synergies of Postural Control in Self-and External-Triggered Force Release During Simulated Archery Shooting. Journal of Motor Behavior, 55(3), 289–301. https://doi.org/10.1080/00222895.2023.2187336

Subramaniam, A., Zainudin, F. F., & Txi, M. R. S. (2026). Systematic Review of Exercise Interventions in Archery: Injury Management and Performance Outcomes. Physical Education Theory and Methodology, 26(1), 80–95. https://doi.org/10.17309/tmfv.2026.1.06

Sung, L., Kesha, K., Avedschmidt, S., Root, K., & Hlavaty, L. (2018). The modern compound bow. Journal of Forensic Sciences, 63(1), 130–139. https://doi.org/10.1111/1556-4029.13503

Susanto, S., Siswantoyo, S., Prasetyo, Y., & Putranta, H. (2021). The effect of circuit training on physical fitness and archery accuracy in novice athletes. Physical Activity Review, 1(9), 100–108. DOI 10.16926/par.2021.09.12

Wibowo, M. S. R., Sukamti, E. R., Prasetyo, Y., Paryadi, Buhari, M. R., Hudah, M., … Virama, L. O. A. (2022). Content Validity and Reliability Test of Balance Training Program for Archery. International Journal of Human Movement and Sports Sciences, 10(3), 378–383. https://doi.org/10.13189/saj.2022.100303

Xu, N., Yan, W., Sun, M., Li, R., Wang, Y., & Chi, L. (2023). Applying skill-oriented and spirit-oriented psychological training to Chinese national archery team athletes: a single-case mixed-methods study. International Journal of Sport and Exercise Psychology, 3(4), 1–27. https://doi.org/10.1080/1612197X.2023.2168724

Yachsie, B. T. P. W. B., Nasrulloh, A., Prasetyo, Y., Suhasto, S., & Skaliy, A. (2024). Application of push-ups and pull-ups to develop strength endurance of arm muscles in archery athletes. Health, Sport, Rehabilitation, 10(3), 28–38. https://doi.org/10.58962/HSR.2024.10.3.28-38

Yacshie, B. T. P. W. B., Prasetyo, Y., & Arianto, A. C. (2022). Walk back tuning and paper tuning: How do they improve archery accuracy? Journal Sport Area, 7(1), 59–68. https://doi.org/10.25299/sportarea.2022.vol7(1).7105

Zanevskyy, I., & Zanevska, L. (2023). Testing and Tuning of the Sport Archery Bow and Arrow System. International Journal of Sport Culture and Science, 11(2), 132–149. https://izlik.org/JA68KP58HC

Authors and translators' details:

Betrix Teofa Perkasa Wibafied Billy Yachsie	betrixbilly@uny.ac.id	Author
Heru Prasetyo	heruprasetyo@uny.ac.id	Author
Danny Eka Wahyu Saputra	dannyeka@uny.ac.id	Author
Yudik Prasetyo	yudik@uny.ac.id	Author
Mohd Izwan Shahril	izwan.shahril@fsskj.upsi.edu.my	Author