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Original Article

Acute effects of guided imagery on archery shooting performance, heart rate variability, and ERP responses

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Abstract:
The purpose of this study was to examine the acute effects of PETTLEP-based guided imagery on shooting performance and psychophysiological responses in archery athletes. Although imagery training has been widely applied in sport psychology, evidence regarding its simultaneous acute effects on autonomic regulation, cortical cognitive processing, and shooting performance, particularly in archery, remains limited. Therefore, this study employed an integrated approach to shooting performance and psychophysiology, examining HRV and ERP. Twelve young archery athletes participated in a within-subject pre-post experimental design. Heart rate variability parameters, including the SDNN, RMSSD, and mean heart rate, were recorded using ECG, whereas the ERP P3 amplitude and latency were obtained using EEG. Shooting performance was evaluated based on the accuracy score and shooting precision. The results showed that imagery significantly increased SDNN (p = 0.006) and RMSSD (p = 0.001) and decreased the mean heart rate (p = 0.009), indicating parasympathetic nervous system dominance and a more optimal state of relaxation. Shooting precision also improved significantly, as reflected in a reduced single radial deviation, whereas shooting accuracy improved but did not change significantly. Moreover, the ERP P3 amplitude and latency showed small but non-significant changes. These findings indicate that the acute effects of guided imagery are more pronounced on autonomic regulation and motor stability than on higher-level cognitive processing. Overall, guided imagery provides meaningful acute benefits that can be utilized as a pre-performance preparation strategy for archery athletes and has the potential to be integrated into psychophysiology-based training systems. Future studies should include larger sample sizes, control groups, and longer intervention periods to further explore the neural mechanisms and long-term effects of imagery training in archery.
Keywords: Archery Performance; Psychophysiology; Guided Imagery; HRV; ERP

Introduction

Understanding of archery performance has evolved alongside advances in sports science and technology, where performance is no longer measured solely based on technical skill. Archery is a precision sport that requires optimal integration of the physical conditions (Susanto et al., 2021), neuromuscular coordination (Liao et al., 2022), and psychophysiological regulation (a combination of mental training and monitoring of physiological states) (Corrado et al., 2024; Fronso et al., 2017; Navabinejad & Rostami, 2023), including the ability to maintain attention and bodily relaxation (Feng, 2023; Wang et al., 2022). This integration directly determines performance through the accuracy and precision of the athlete's shoots within a brief timeframe (Gu et al., 2022). Every phase of the archery technique, from setup, draw, aiming, clicker-release time, to follow-through, can be a critical moment influencing overall performance (Jacquot et al., 2025), thus requiring optimal parasympathetic regulation and neural control even under competitive pressure. This is supported by findings (C. Zhao et al., 2024) showing that better athlete performance is correlated with greater parasympathetic nervous system activity, and by (Yongtawee et al., 2021) who reported that an athlete's ability to maintain psychological stability is a crucial factor in optimizing performance outcomes. Finally, findings by (Zemková & Zapletalová, 2022) suggest that enhanced neuromuscular control can lead to a more efficient technique. An approach that is capable of optimizing psychophysiological conditions is therefore imperative for improving archery athletes' performance.

One widely used approach is imagery training, a cognitive technique that involves visualizing skills and performance scenarios through mental rehearsal (Kurniawan et al., 2021). Various literature reviews confirm that imagery is an essential skill for athletes because it can improve specific motor abilities and psychological readiness (Lindsay et al., 2023; Liu et al., 2025; Rhodes et al., 2024). In its development, PETTLEP has become an imagery model that maximizes the functional equivalence between imaginary experiences and real performance (Holmes & Collins, 2001), making it relevant to sports with high technical demands such as

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archery. This model comprises seven components, namely, physical, environment, task, timing, learning, emotion, and perspective, implemented through a guided imagery approach (Volgemute et al., 2025) by creating mentally equivalent training experiences (Scott et al., 2022; Woolsey et al., 2020). Guided PETTLEP introduces imagery to athletes and enables them to maintain optimal performance under the pressure of competitive situations (Janjigian, 2024; Simonsmeier et al., 2021; Yalçin et al., 2022). Specifically, the PETTLEP model is designed to produce acute performance improvements (Rhodes et al., 2024), and even a single training session can significantly reduce athletes' anxiety levels (Indahwati & Ristanto, 2016). However, the application of the PETTLEP model in archery, particularly to comprehensively examine its acute effects, remains relatively limited, despite its recognized theoretical and practical urgency.

To understand the acute mechanisms of imagery interventions, an objective measurement approach that can reliably represent athletes' psychophysiological responses is needed. Heart rate variability (HRV) provides robust information regarding autonomic function, particularly as an indicator of the balance between the sympathetic and parasympathetic systems (Hinde et al., 2021). Common HRV parameters in the time domain include the mean heart rate (HR) as a general indicator of cardiovascular activation; the standard deviation of normal-to-normal intervals (SDNN), which reflects the parasympathetic component and mediates responses to mental stress (Yilmaz et al., 2018); and the root mean square of successive differences (RMSSD), which represents short-term heart rate variability while reflecting the integrity of vagus nerve-mediated cardiac autonomic control (Amekran et al., 2025; Lee et al., 2023). Through this, it can represent the physiological changes in athletes in response to imagery.

Along with HRV measurements, event-related potentials (ERP) provide information on time-dependent fluctuations of electrical activity, reflecting neural responses to sensory, cognitive, or motor stimuli (Bradley & Keil, 2012; Sokhadze et al., 2017; Sur & Sinha, 2009). ERP have been widely used as indicators for evaluating psychological processes, particularly those related to cognitive function (Beres, 2017). Among the various primary ERP components, P3/P300 (a positive deflection at 250-500 ms post-stimulus) (Bradley & Keil, 2012; Rodríguez-Bermúdez et al., 2025) is a relevant component in cognitive research on archery. Specifically, the P3 component provides information regarding cognitive functions such as attention and memory (Polich, 2007), where the optimal allocation of attention to relevant stimuli is a key factor in the success of a shoot (Shao et al., 2022). The ERP Parameters include latency, which indicates the speed of information processing, and amplitude, which represents the level of attention allocated to the stimulus (Sur & Sinha, 2009). Through this, ERP can represent the psychological changes in athletes in response to imagery.

Psychophysiological indicators such as HRV and ERP have been identified as objective parameters for evaluating and improving athlete performance, particularly in precision sports such as archery. HRV measurements are performed using an electrocardiography (ECG) sensor that records electrical signals in the heart to analyze the autonomic nervous system (Zuern et al., 2026), whereas ERP is measured using an electroencephalography (EEG) sensor that records the electrical fields generated by neuronal activity in the brain (Astuti et al., 2024). Advances in the portability of this technology enable more efficient measurements under dynamic sports conditions (Wijaya et al., 2024; J. Zhao et al., 2024). Several previous studies on archery have analyzed ERP responses during the shooting process (Ertan et al., 2021; Vogt et al., 2017) and physiological responses via HRV during shooting (Dal et al., 2024; Tok et al., 2020), as well as the effects of imagery interventions on shooting performance (Isar et al., 2022; Wattimena et al., 2025; Yachsie et al., 2023). However, the approaches in these studies have been analyzed separately and have not yet been integrated into a comprehensive psychophysiological framework.

Although previous studies have examined imagery training, HRV responses, ERP activity, and shooting performance in archery, these variables have generally been investigated separately. Limited evidence is available regarding how PETTLEP-based guided imagery simultaneously affects autonomic regulation, cortical cognitive processing, and shooting performance. Therefore, an integrated psychophysiological approach is needed to clarify whether acute imagery training produces immediate changes across physiological, neural, and behavioral domains. In the absence of an integrative understanding, the design of psychophysiological training programs in archery will remain incomplete and speculative. Given that studies on the PETTLEP imagery model are still limited, the literature lacks multimodal analyses that simultaneously integrate these three dimensions to validate the acute effects of imagery interventions. This study aims to address this gap by analyzing the acute effects of imagery on HRV (SDNN, RMSSD, and HR) and shooting performance in archery athletes, and by further confirming these effects through ERP P3 amplitude and latency. The findings of this study provide a theoretical understanding of the underlying effects of imagery on psychophysiological changes and archery performance, while also offering practical contributions to the development of training systems that integrate simultaneous multimodal measurements.

Material & methods

Participants

All participants provided written consent before participating in this study. The participants consisted of 12 archery athletes aged 12-15 years (M = 13.92, SD = 0.90) at the time of data collection, with 2-10 years of training experience (M = 5, SD = 2.13). The number of participants was obtained from the available archery athletes at the Surakarta Sports School. The participant criteria included: having competed at least once at the regional level, being right-handed, and having never received mental training before. The Participants underwent structured interviews to obtain basic health information, including a history of physical injuries, an eye condition, age, training intensity, and a history of heart and brain health.

Experimental Procedure

This study employed a within-subject pre-post experimental design, in which each participant served as his or her own control. The study was designed with two conditions: psychophysiological status and shooting performance before and after receiving imagery. This design allows athletes to serve as their own controls, reducing inter-individual variability and increasing sensitivity to detect changes in psychophysiological status and shooting performance within a small sample. The experiment was conducted in a controlled experimental room to simulate indoor archery and consisted of a single session to observe the acute effects of PETTLEP-based imagery. There were three stages in this experiment: a pre-training session (baseline performance), a training session (imagery), and a post-training session.

The participants were first introduced to the concept and procedure of imagery training. The athletes then performed a warm-up routine, calibrated their aiming sensor on the smart bow by adjusting the height of the grip while aiming at the target displayed on the TV screen, attached EEG and ECG sensors, and practiced using the smart bow for 10 shots, as illustrated in Figure 1(A). The smart bow device was connected to the Wonderfitter app, which provides an Olympic archery training experience, as illustrated in Figure 1(B). The first stage began with participants standing 1.5 meters from a 43-inch TV, and then taking 15 shots within a 30-second time limit per shot. During this period, shoot scores were recorded, and EEG and ECG signal data were collected. In the second phase, the participants were given a 5-minute rest period before proceeding to the imagery training session. In the third phase, under the same position and conditions, the participants performed another 15 shots. During this phase, the shot scores as well as the EEG and ECG signal data were again recorded as post-imagery training data.

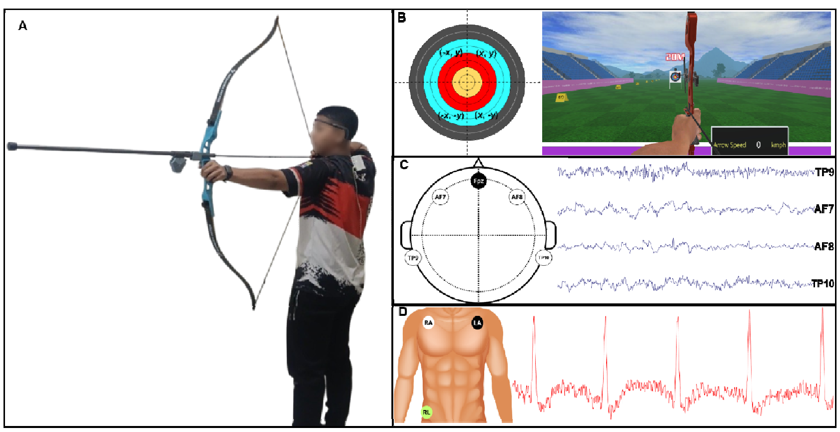

Fig 1. Archery Athletes Shooting Process (A), Wonderfitter Olympic Archery Training (B), EEG Signal (C), ECG Signal (D)

PETTLEP Imagery Training

This PETTLEP-based imagery has been adapted from studies by (Holmes & Collins, 2001; Scott et al., 2022) to be suitable for archery athletes who have never practiced imagery. The exercise is conducted using a 7-minute audio recording played from a laptop. During the exercise, athletes sit in a relaxed position in a quiet room with their eyes closed to make it easier to imagine the guidance in the recording. During the first 30 seconds of the training, athletes are asked to inhale and exhale within a specific time frame to relax during the imagery training session. The training includes the following seven components: (physical; archery athletes imagine their posture when shooting, including the position of their feet, hands, and drawing the string); (environment; imagining the atmosphere of the competition events with a gentle breeze and the sound of the audience); (task; imagining motor processes such as drawing, anchoring, aiming, releasing the arrow, and follow-through); (timing; training was conducted following the sequence of events in a competition); (learning; training was tailored to the skill level of young athletes and included verbal cues and routine repetition); (emotional; athletes felt self-confidence, calmness, and pride in their shooting results); and (perspective; athletes were guided to adopt an external perspective by imagining themselves competing from the viewpoint of others). These seven components create an imaginative experience that resembles real archery competition conditions.

EEG and ECG Processing

The EEG data were acquired using a Muse 2 headband at a sampling rate of 256 Hz. The device consists of four channels, namely AF7, AF8, TP9, and TP10, whose placement follows the "International 10-20" system (Pivik et al., 1993), as illustrated in Figure 1(C). The recorded data were then processed in MATLAB using EEGLAB. The EEG data processing steps included band-pass filtering (1-30 Hz), ICA decomposition, importing time markers (when the athlete aimed), and epoching from -200 ms to 800 ms. Data from each participant's channels were combined into a single dataset to generate a grand average. Next, the peak amplitude and peak latency of the ERP P3 component were manually determined from the signal visualization.

The ECG data were acquired using a Bitalino Plux device configured with a 3-lead electrode cable and a sampling rate of 1000 Hz. Three disposable electrodes (HR-OP55) were placed with the positive electrode (LA) below the clavicle near the left shoulder, the negative electrode (RA) below the clavicle near the right shoulder, and the reference electrode (RL) on the lower right abdomen. ECG sensor placement followed the standard position by Mason-Likar modification (Francis, 2016), as illustrated in Figure 1 (D). ECG data processing included detrending, band-pass filtering (0.5-150 Hz), a 50 Hz notch filter to remove noise, and data smoothing with a median filter. Next, R-wave peak detection (QRS detection) is performed to determine the RR interval, which is then used to calculate HRV parameters using an algorithm in MATLAB.

Shooting Performance Measurement

The archery device used to measure shooting performance (accuracy and precision) is the Houyi 2 smart bow from Wonderfitter. This is a digital archery device equipped with position and motion sensors. Each shot generates a score representing accuracy, which is then used to calculate the shot precision. Shot accuracy refers to the closeness of the shot to the center of the target, whereas shot precision refers to the consistency or closeness between shots (Zhang & Lin, 2024). The precision is calculated by plotting Cartesian coordinates for each shot, where the coordinates depend on the target face diameter of 122 cm. The center of the target is set at (0,0); the horizontal axis (x) represents the left-right direction, whereas the vertical axis (y) represents the up-down direction of the target, as illustrated in Figure 1 (D). The value of ($\bar{x}$) represents the average variation in the horizontal direction (x-variance), whereas the value of ($\bar{y}$) represents the average variation in the vertical direction (y-variance). Shooting precision is calculated based on the Euclidean distance between each shot and the average coordinates of all shots, using the single radial deviation (SRD) as adapted from previous studies (Moon & Lee, 2024; Zivkovic et al., 2019). A larger SRD value represents lower shooting precision. Thus, a smaller SRD value indicates higher shooting precision.

Statistical Analysis

Prior to the comparative test, the Shapiro-Wilk test for normality and Levene's test for homogeneity were performed to check the assumptions for parametric statistics. To analyze shooting performance, EEG data and ECG data, a paired sample t-test was implemented. This test had two data sets: pair 1 was the data collected prior to training, and pair 2 was the data collected after the training. Effect size was calculated using Cohen's d to quantify the magnitude of the training effect in terms of standard deviation units. All the statistical analyses were performed using SPSS software, with $p \leq 0.05$ and $p \leq 0.01$ indicating statistical significance.

Results

Table 1. Comparison Results

Indicator	Parameter	Pre-Training		Post-Training		Effect Size		
		M	SD	M	SD	p	t	Cohen's d
HRV	SDNN	44.64	14.49	56.20	12.28	0.006**	-3.39	0.86
	RMSSD	33.08	12.20	41.60	10.29	0.001**	-4.20	0.75
	HR	111.02	8.08	108.31	5.56	0.009**	3.17	0.25
ERP	Peak Amplitude	8.23	2.85	8.38	3.38	0.880	-0.15	0.05
	Peak Latency	319.73	27.67	315.35	28.94	0.658	0.46	0.15
Shooting	Accuracy	131.17	11.23	133.83	6.81	0.231	-1.27	0.29
	SRD	11.00	5.17	9.03	2.59	0.044*	2.27	0.48

Note: *$p<0.05$, **$p<0.01$ M= Mean, SD = Standard deviation

Specifically, the results of the ECG, EEG, and shooting performance measurements from this study are presented in Table 1 and Figure 2. The HRV indicator based on ECG measurements using the SDNN parameter showed a statistically significant increase in the mean from (M = 44.64 ms, SD = 14.49) to (M = 56.20 ms, SD = 12.28) after imagery training. A paired samples t-test results indicate that this decrease is significant (p = 0.006, t = -3.39), with an effect size (Cohen's d = 0.86) falling into the large effect category. The RMSSD results also indicate a statistically significant increase in the mean from (M = 33.08 ms, SD = 12.20) to (M = 41.60 ms, SD = 10.29) after imagery training. A paired-samples t-test showed that this decrease was significant (p = 0.001, t = -4.20), with an effect size (Cohen's d = 0.75) falling into the moderate effect size category. Moreover, the mean HR decreased significantly from (M = 111.02 bpm, SD = 8.08) to (M = 108.31 bpm, SD = 5.56) after imagery training. A paired-samples t-test showed that this decrease was significant (p = 0.009, t = 3.17), with an effect size (Cohen's d = 0.25) in the small effect category.

The ERP indicator, based on EEG peak amplitude measurements, showed a statistically significant increase in the mean value from (M = 8.23 µV, SD = 2.85) to (M = 8.38 µV, SD = 3.38) after imagery training. A paired samples *t*-test results indicate that this increase is not statistically significant (p = 0.88, t = -0.15), with an effect size (Cohen's d = 0.05) falling into the very small effect category. Moreover, the results for peak latency (P3) show a shorter latency time to reach the peak. Statistically, the mean decreased from (M = 319.73 ms, SD = 27.67) to (M = 315.35 ms, SD = 28.94) after imagery training. A paired-samples *t*-test showed that this decrease was not significant (p = 0.658, t = 0.45), with an effect size (Cohen's d = 0.15) falling into the very small effect size category. The grand average ERP is shown in Figure 3 below.

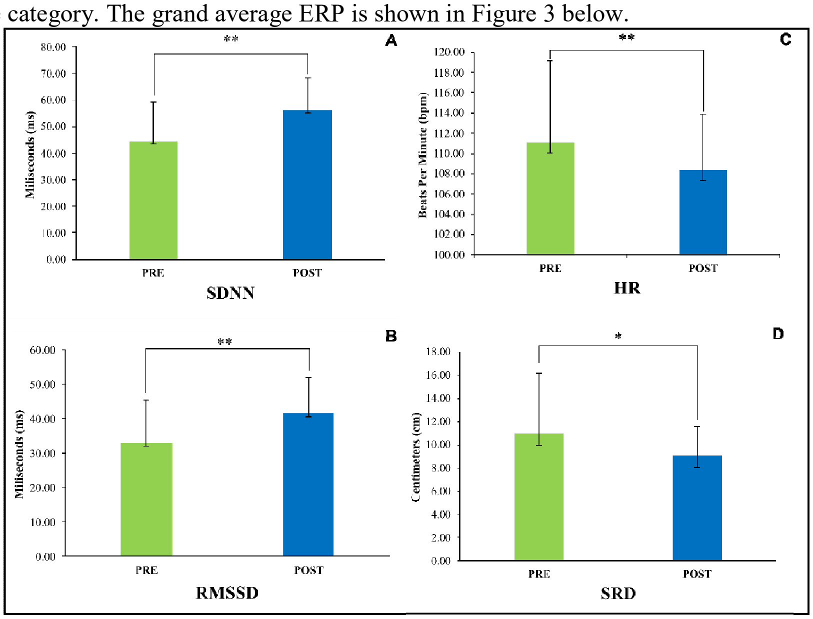

Fig 2. Comparison of Results for (A) SDNN, (B) RMSSD, (C) HR, (D) SRD

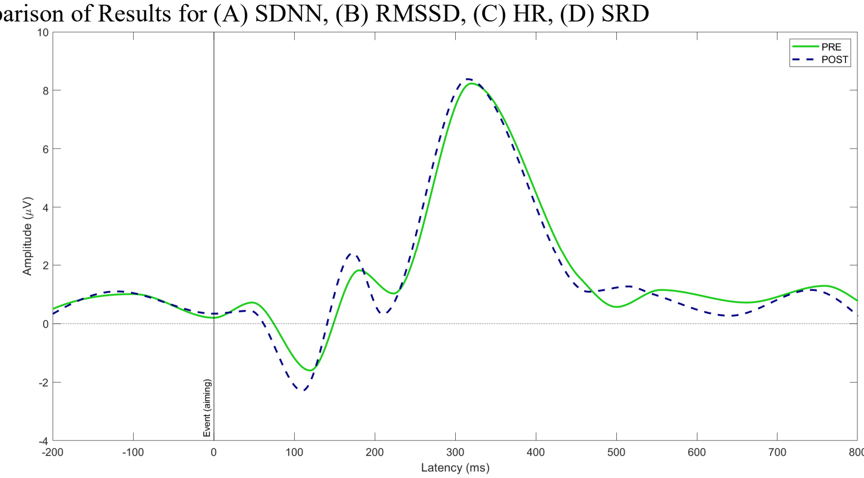

Fig 3. Grand Average ERP of Archery Athletes

The shooting performance indicator based on accuracy showed a statistically significant increase from (M = 131.17, SD = 11.23) to (M = 133.83, SD = 6.81) after imagery training. A paired samples *t*-test results indicate that this increase is not statistically significant (p = 0.231, t = -1.27), with the effect size (Cohen's d = 0.29) falling into the small effect category. Moreover, the precision results showed improvement, as evidenced by a decrease in the SRD value. Statistically, the mean decreased from (M = 11.00 cm, SD = 5.17) to (M = 9.03 cm, SD = 2.59) after imagery training. A paired-samples *t*-test showed that this decrease was significant (p = 0.044, t = 2.27), with an effect size (Cohen's d = 0.48) falling into the small effect size category.

Discussion

This study aims to analyze the acute effects of imagery training on archery athletes based on HRV (SDNN, RMSSD, HR), ERP P3 (peak amplitude, peak latency), and shooting performance (accuracy and precision). In general, PETTLEP imagery produced significant acute effects on changes in all HRV parameters and shooting precision. However, it did not significantly affect on changes in any ERP parameters and shooting accuracy.

Increases in the SDNN and RMSSD values, accompanied by a significant decrease in mean HR during the shooting process, indicate increased parasympathetic nervous system activity and cardiac vagal tone in response to the imagery intervention. Theoretically, increases in the SDNN and RMSSD to moderate-to-high levels indicate enhanced vagal tone, which promotes a calmer and more relaxed state (Zeng et al., 2023). The accompanying decrease in the mean HR is a natural response to parasympathetic nervous system activation, which slows the heart rate and makes the body feel more comfortable (Benz et al., 2022). Overall, this pattern of HRV changes aligns with the concept of functional equivalence in the PETTLEP-guided imagery model, successfully activating physiological conditions comparable to the regulated relaxation state required by the archery athlete during the shooting process. These findings are similar to those of (Lin, 2017), who reported that the PETTLEP-based imagery model enhanced self-confidence, decreased anxiety, and promoted positive emotions among archery athletes. These effects collectively help increase body relaxation (Toussaint et al., 2021). This is also supported by prior studies that have consistently shown that imagery training results in a decrease in anxiety levels in archery athletes (Indahwati & Ristanto, 2016; Kim & Chang, 2020), and also by (Lee et al., 2023), who have specifically reported increases in the values of SDNN and RMSSD in athletes of precision sports after imagery training.

Moreover, the ERP P3-based neural perspective in this study reflects the brain's response in athletes when processing target faces during the drawing to aiming phase. The study results demonstrate that imagery training leads to increased peak amplitude and shorter peak latency, which, theoretically, reflect a brain state of increased attention and faster processing of the target stimulus (Bradley & Keil, 2012; Polich, 2012). However, these factors did not result in statistically significant changes. Given that the participants in this study were relatively experienced young athletes, they theoretically already possessed the ability to maintain attention at an optimal level to support successful performance (Lu et al., 2021). This ability to regulate attention likely developed through accumulated training and competitive experience; therefore, a single session of guided imagery was not sufficient to produce a significant acute effect on attention. On the other hand, the PETTLEP-guided imagery model is based on the activation of neural representations via functional equivalence. The absence of significant effects is probably not due to the ineffectiveness of the imagery mechanism itself but rather to the methodological limitations, specifically the small sample size, the number of shooting trials, and the duration of the training session, which resulted in relatively limited ERP data. The accumulation of these factors reduces the sensitivity of detecting changes in brain activity levels. Thus, the acute effect of a single imagery session was insufficient to produce statistically detectable changes in the ERP P3 parameter in the context of the archery shooting process.

The study's findings regarding shooting performance indicate that acute imagery improved shooting precision, as evidenced by a significant decrease in SRD values. However, shooting accuracy showed only a non-significant increase. This increase in accuracy indicates that shooting patterns become more stable, suggesting that imagery plays a role in improving athletes' fine motor control. This is relevant to archery, a sport that demands motor skills to control fine muscles to produce more consistent shots (Pelana & Oktafiranda, 2022). These findings are consistent with previous studies demonstrating the effectiveness of imagery training in improving motor skills and overall athletes' performance (Ladda et al., 2021; Lindsay et al., 2023). Furthermore, changes in HRV indicators reflecting a more optimal state of physiological relaxation (as discussed earlier) are theoretically closely linked to improved fine motor control in archery (An et al., 2025), particularly regarding stability during the aiming and release phases, thereby indirectly contributing to shot consistency. These findings suggest a possible association between improved autonomic regulation and enhanced shooting precision; however, mediation analysis or experimental modification is needed to confirm this pathway. As for shooting scores, they showed a statistically non-significant increase. The findings of this study differ from those of (Wattimena et al., 2025; Yachsie et al., 2023), who reported improvements in accuracy and shooting ability following imagery interventions at distances of 40 meters and 20 meters, respectively. This difference may be due to differences in the interventions, as those studies did not limit themselves to measuring acute responses but rather focused on cumulative effects over multiple weeks. This is confirmed by (Itoh et al., 2022), who reported that long-term imagery training provides the greatest benefits for improving athletes' performance. Thus, the findings of this study indicate that acute imagery plays a greater role in improving the consistency of archers' movements than in improving their ability to hit the center of the target accurately.

Overall, the findings of this study indicate that the PETTLEP-guided imagery model has a partial acute effect on the shooting performance and psychophysiological state of archery athletes. Through simultaneous measurements, this study demonstrated that imagery modulates function toward a calmer state during shooting, thereby stabilizing fine motor activity and improving shooting precision. On the other hand, psychological indicators, including the amplitude and latency of the ERP P3, did not significantly change, thus failing to confirm an acute increase in cognitive processing efficiency during the aiming phase. Consequently, these findings suggest that, within an integrative psychophysiological framework, the acute effects of imagery are more pronounced in autonomic regulation than in cortical modulation. These findings also open opportunities for developing more comprehensive, science-based training systems.

In addition, the archery device used was a smart bow. This device resembles a real recurve bow and can provide an experience similar to real-world conditions (Yasumoto, 2022). However, the device in this study functions solely as a measuring tool; the technology, which is equipped with motion and position sensors, offers potential for innovation in archery training, especially when integrated with imagery. This integration can serve as biofeedback to align mental imagery with real performance, thereby enhancing motor control (Mitsea et al., 2023). Consequently, the findings of this study can be applied in real-world settings. Practically speaking, given the demonstrated acute effects, the PETTLEP-guided imagery model can be utilized by archers as a pre-competition preparation to enhance bodily relaxation and stabilize their shots. Archery coaches can also integrate this guided imagery training model into training and pre-performance routines to help athletes achieve a more optimal physiological state. Additionally, simultaneous monitoring of HRV and ERP can serve as indicators of athletes' mental and physiological readiness when facing competitive pressure.

Despite these findings and contributions, this study has several methodological limitations. First, the absence of a control group reduces the ability to isolate the pure effects of the guided imagery intervention, as other external factors could influence both shooting performance and the observed physiological changes. Second, the small sample size increases the risk of underfitting and limits the validity and generalizability of the findings. Third, a single session of guided imagery is insufficient to produce significant changes in the ERP. Fourth, the number of trials or shots in the ERP dataset is relatively limited, which may affect the accuracy of parameter estimates. These limitations require caution in interpreting the findings and highlight opportunities for future research to generate more comprehensive and holistic evidence.

Given these limitations, future studies are recommended to expand the experimental design by including a control group to identify the pure acute effects of guided imagery, increase the sample size to enhance validity and strengthen the generalizability of the study's findings; extend the duration and number of sessions to evaluate long-term effects; and use multi-band EEG analysis as a psychological indicator to deepen the understanding of the neural mechanisms involved in archery.

Conclusions

The results of this study indicate that guided imagery produces a partial acute effect on psychophysiological responses and shooting performance. Imagery significantly enhances autonomic nervous system regulation by increasing the HRV (SDNN and RMSSD) and decreasing the mean HR, indicating parasympathetic dominance and contributing to improved motor stability, as reflected by a significant increase in shooting precision. The shooting scores (accuracy) also showed an average increase, though not statistically significant, indicating that the acute effects of imagery were not yet strong enough to modulate other or more complex aspects of performance. Similarly, ERP P3 parameters (amplitude and latency) did not show significant changes either, thus failing to confirm an acute improvement in cognitive processing efficiency through imagery. Through the method and results, which employed a simultaneous measurement approach of HRV, ERP, and shooting performance, the findings of this study theoretically become essential and contribute to a more comprehensive understanding of archery and demonstrate that the acute effects of guided imagery are more dominant in influencing autonomic regulation and movement stability than are higher-level cognitive processes. From a practical standpoint, these findings support the evidence-based use of guided imagery in pre-competition routines to induce calmness and stabilize shots. Additionally, the findings highlight the potential of HRV and ERP as indicators for monitoring athletes' physiological and cognitive readiness, thereby supporting the development and implementation of psychophysiologically based training systems in archery that allow coaches and sports scientists to verify the results objectively. However, to assess the acute effects of guided imagery more accurately, future studies should employ larger sample sizes, include control groups, utilize longer intervention periods, and expand the exploration of feature extraction from EEG data.

Conflicts of interest

The authors declare no potentials conflicts of interest.

Declaration of generative AI and AI-assisted technologies in the writing process

The authors declare that during the writing process, this study used ChatGPT (OpenAI) to improve clarity, readability, and refine the academic writing style. After using this tool/service, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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Institutional Review Board Statement

This study has obtained ethical approval issued by the Health Research Ethics Committee (HREC) of dr. Moewardi Regional General Hospital with ethical number 612/III/HREC/2025.

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