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Electric camera sensor vs. virtual reality archery: Which is more effective for improving archery accuracy?

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ABSTRACT

Background: The integration of technology into archery training has gained attention, yet limited studies have compared the effectiveness of electric camera sensors and virtual reality (VR) systems in enhancing archery accuracy. The lack of clear data regarding how each method impacts arrow speed and accuracy necessitates further investigation. **Research Objectives:** This study aims to compare the effectiveness of two training approaches—electric camera sensor-based training and VR archery—in improving arrow accuracy and speed, and to evaluate their implications for bow performance and technique assessment. **Methods:** A quantitative experimental design with a two-group pretest-posttest approach was employed. The study involved 20 male archers aged 15-20 years, selected via purposive sampling. Participants underwent 18 training sessions using a fixed shooting distance of 40 meters. Data were collected on arrow accuracy and analyzed using paired and independent t-tests. **Finding/Results**: The study found that both training methods significantly improved archery accuracy. However, athletes who trained using the electric camera sensor showed slightly greater improvements than those using virtual reality. The sensor-based training provided more precise feedback on arrow speed and trajectory, which enhanced technique evaluation and led to better shooting outcomes. These results highlight the sensor's potential as a more effective tool for refining archery performance. **Conclusion:** Fixed-distance training using an electric camera sensor system is more effective than virtual reality archery in enhancing archery accuracy. The integration of arrow speed motion sensors facilitates more precise evaluations of bow technique and performance, particularly when inconsistencies in arrow trajectory occur. It is recommended for archers seeking improvements in accuracy to incorporate electric camera sensor technology into their training.

Keywords: Archery accuracy; electric camera sensor; virtual reality archery; fixed-distance training; arrow speed

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INTRODUCTION

Archery is a sport that uses accuracy supported by arm muscle endurance as the main element that every athlete must have (Wibowo et al., 2022). Achieving success in the sport of archery requires special abilities,

including accuracy, coordination, mental and physical condition (Suhasto et al., 2023). Training is defined as a process to prepare the athlete's organism systematically to achieve maximum performance quality by providing physical and mental loads regularly, directed, graded, and repeated over time (Sabillah et al., 2022).

The fixed distance drill method is a method that aims to improve archery techniques and skills (Low et al., 2023). Besides that Saing et al. (2022) states that the fixed distance drill method is included in closed motor learning, meaning that someone does something with a fixed environment, so that an athlete can control it and plan it in advance and is easy to control and plan by the athlete himself. So, the fixed distance drill method training will be very useful and it is hoped that using this method can improve efficient and perfect archery accuracy.

Accuracy is the main thing in archery that must be mastered by athletes (Susanto et al., 2021). In terms of accuracy, athletes are not required to have perfect technique, but an archer is required to have good shooting accuracy supported by technique or stability (Haywood & Lewis, 2013; Samah et al., 2019; Vendrame et al., 2022). If the technique is good and right, it will produce good shots and accuracy, it is imagined that there is a target or point that must be aimed at or hit with a certain object. It can be concluded that previous research only provides training or treatment to athletes, not trying to provide treatment to the tools/bows/consistency of arrow movements used by the athletes. This latest innovation is indeed needed to improve the precision of the bow combined with the consistency of archery techniques that are always recorded in every movement of the 9 archery techniques, under certain conditions the 9 archery techniques can be realized virtually. In this condition, athletes will easily correct wrong movements when performing archery technique movements. Proven the gap occurs when the observation of archery accuracy shows a decrease in the archery accuracy score, it is shown that there are 32.00% in the very low category, 40.00% of athletes in the low category, 12.00% of athletes in the sufficient category, and 16.00% of athletes in the good category. The training program provided by the trainer so far has used more drilling methods, but variations in training using digital have not been considered (Bergamo et al., 2022). Often archers do training with a combination of weight training, and this mental hese conditions are still not optimal for improving archery accuracy so appropriate technological aspects are needed to optimize archery abilities (Suhasto et al., 2023). An example of drilling exercise conducted during training is archery athletes with a fixed distance and do not utilize technology to improve archery accuracy.

Achieving success in the sport of archery requires special abilities, including accuracy, coordination, mental and physical condition (Jogi et al., 2024). The drill method is good for training, especially when practicing skills in a particular sport (Putri et al., 2024). Skills are given using the drill method because the same movements are done repeatedly, so that an athlete will remember them when doing the movement (Rohadi et al., 2021). The characteristic of archery is releasing arrows along a certain trajectory towards a target at a certain distance (Raphals, 2022). This means that archery requires precision that is consistent and stable in movement so that the arrow hits accurately, so that drill training is interpreted as very suitable for increasing the accuracy of archery. However, this drill must be combined with the right training so that it provides maximum effect.

Arrow speed motion sensor analysis is a tool that every coach needs to have, while virtual reality archery is a training tool to train and condense between techniques, thoughts and arrow speed movements to achieve a high point of accuracy. This condition is very urgent, so that the accuracy of the archery will increase. The gap occurs when archers often do not feel that the tools used are not right. They assume that technique is one of the most important elements, while the tools and precision of the arrow speed are the result of the technique. So when athletes shoot with a score of 348 they stop at that score. Unwittingly the highest score from archery is 360 so that archers experience difficulties and are stuck on results that do not change. So the difference between this study and previous studies is that evaluation and finding a match between the two tools needs to be done to increase the straightness of the arrow speed to the intended point and the accuracy of archery. Electric camera sensors are a development of sports mechanical applications. If biomechanics is a human body movement system for electricity, the camera is a special version for seeing the movement of arrows released by archers. With these rotations and fast movements, it is known that the weakness of the tuning carried out in the sport of archery affects archery accuracy. Meanwhile, virtual reality is a training tool used to see the

technique and release of arrows which is carried out as a means of seeing archery movements and archery releases which are carried out with the help of digital technology, so that errors in releasing arrows can be evaluated with the aim of increasing archery accuracy.

METHOD

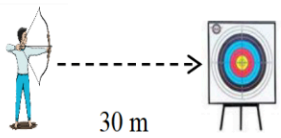
This type of research is an experimental two-group pretest-posttest design. The population consists of archery athletes in Indonesia and Malaysia, and a sample of 20 people was determined by purposive sampling with the criteria of male gender, In detail, namely, (i) the number of archers studied were archery athletes in the beginner category taken based on actively participating in archery for 6 months/having participated in regional championships in Indonesia/Malaysia; (ii) National is taken with the qualification of having participated in a national championship or participated in a competition representing a province in Indonesia/Malaysia; (iii) Elite are athletes with qualifications to represent Indonesia/Malaysia. Meanwhile, this age group is the sample age, with an age range of 15-20 years.

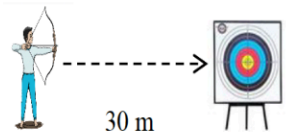
Table 1. Characteristics of the Participant Subjects

Level	Country	Gender	Age	Total	Career (year)
Beginner	Indonesia		15-17	4	< 2
National	and	Male	15-20	10	> 5
Elite	Malaysia		20	6	> 8

The sample then took a pretest, was sorted by pretest score, and was then paired with the ABBA (Ordinal Pairing) pattern. It was found that 10 athletes were done using an electric camera sensor, and 10 athletes were trained using virtual reality archery. The division of the group in this way will be more objective for all research subjects. Universitas Negeri Yogyakarta has issued an ethical clearance letter to support this research. The training implementation procedure was carried out for 6 weeks with 18 meetings. The training is in the form of progressive, electric camera sensor training as much as 72X at a distance of 30 meters. Then virtual reality archery training as much as 72X at a distance of 30 meters. The repetition of archery in this training is 2 sessions, following the rules of World Archery, namely 1 session containing 6x series, with 1x series containing 6 arrows released. The previous training program has received validation from three archery experts and one archery coach. Table 1 provides further details.

Table 2. Electric Camera Sensor vs Virtual Reality Archery Drilling Training Program

Week	Meeting	Training material	Training Dosage
1-6	1-18	1. Procedures and equipment a) Athletes are guided to perform dynamic static stretching. b) Field equipment: shooting targets and meters, wind marker flags. 2. Warm up a) Static, dynamic flexibility and field trials. 3. Electric Camera Sensor  4. Virtual Reality Archery	Coach guide Warm up/stretch for 5 minutes Warm-up/stretch for 5-10 minutes. 2x series: 12 arrows 1. Medium rhythm. 2. Distance 30 Meters. 3. Intensity 65% 4. 2 Sessions. 5. 12x Session, consists of 1 session containing 6 arrows. 6. Recovery 45 minutes.

Week	Meeting	Training material	Training Dosage
			1. Medium rhythm. 2. Distance 30 Meters. 3. Intensity 65% 4. 2 Sessions. 5. 12x Session, consists of 1 session containing 6 arrows. 6. Recovery 45 minutes.
	5.	Cooling down	Cooling down/evaluate for 5-7 minutes

The instrument used is a 40 meter distance archery test ring 6, the highest point is 10/x and the lowest is 5, this test aims to measure accuracy in archery (Yacshie et al., 2022). Archery accuracy is the way an archer shoots 36 arrows from a distance of 30 meters and the total result of each arrow is totaled or called the total score, and the process is called scoring (point) the maximum total score is 360 with content validity of 0.935, and cronbach's alpha reliability of 0.825 (Prasetyo et al., 2022). The statistics used are t-tests. There are two t-tests, namely paired sample test and independent sample test with significance (p 0.05).

RESULTS AND DISCUSSION

The data from this study are in the form of pretest and posttest scores on archery accuracy. The research process took place in three stages: (i) a pretest to obtain baseline data, (ii) group division and treatment, and (iii) a posttest to compare with the pretest data to determine whether there was an improvement. The data were tested for normality using the Lilliefors test (sig. = 0.242) and for homogeneity using Levene's test (sig. = 0.277). Both results indicated that the data were normally distributed and homogeneous, allowing for further analysis.

Table 3 presents the detailed pretest and posttest scores of each participant. The results show that both groups experienced improvements, as indicated by positive score differences in every subject. Meanwhile, Table 4 summarizes the descriptive statistics. It can be seen that the mean posttest score of the electric camera sensor group (M = 323.7) was higher than that of the virtual reality archery group (M = 319.3), suggesting that although both methods improved archery accuracy, the electric camera sensor group achieved better overall performance.

Table 3. Pretest and Posttest Data for Archery Accuracy

No Subject	Score Prediction	Posttest Score	Difference	Score Prediction	Posttest Score	Difference
1	315	332	17	295	312	17
2	313	329	16	316	334	18
3	314	324	10	312	322	10
4	301	312	11	293	310	17
5	309	321	12	312	322	10
6	319	342	23	304	317	13
7	305	317	12	311	327	16
8	310	327	17	304	316	12
9	283	314	31	301	312	11
10	285	319	34	308	321	13

Table 4. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Camera Sensor Electrical Pretest	10	283	319	305.4	12.384
Camera Sensor Electrical Posttest	10	312	342	323.7	9.117
Virtual Reality Archery Pretest	10	293	316	305.6	7.618
Virtual Reality Archery Posttest	10	310	334	319.3	7.469

Figure 1 presents the mean scores of archery accuracy in the pretest and posttest for both training methods: electric camera sensor and virtual reality archery. The striped bars indicate pretest scores, while the solid bars indicate posttest scores. Both groups showed an improvement after the intervention, with the electric camera sensor group increasing from a mean of about 305 to 324, and the virtual reality archery group from about 306 to 319. This figure supports the data in Tables 3 and 4, confirming that both training methods effectively improved archery accuracy, although the electric camera sensor produced slightly better outcomes.

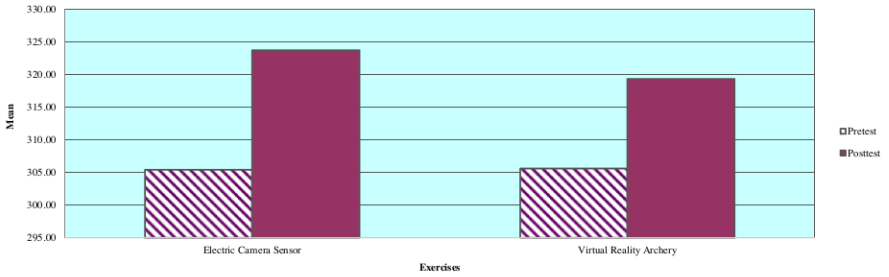


Figure 1. Difference Results from the Two Exercises Given

The results illustrated in Figure 1 show that both training methods contributed to improvements in archery accuracy. However, the posttest scores of the electric camera sensor group were higher, while the virtual reality archery group demonstrated comparatively lower gains. As presented in Table 5, both interventions significantly improved accuracy, with p-values of 0.000 (< 0.05) for both groups, indicating a positive effect of training.

Table 5. Paired Samples Test Electric Camera Sensor and Virtual Reality Archery

		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Camera Sensor Electrical	Pretest-Posttest	-1.830	8.433	2.666	-24.332	-12.267	-6.862	9	.000
Virtual Reality Archery	Pretest-Posttest	-1.780	8.297	2.623	-23.735	-11.864	-6.784	9	.000

Further analysis through an independent samples t-test (Table 6) revealed a significant difference between the two methods ($p = 0.001 < 0.05$). The electric camera sensor group achieved a higher posttest mean score ($M = 323.7$) compared to the virtual reality archery group ($M = 319.3$). This suggests that while both methods enhance accuracy, the electric camera sensor produces more optimal outcomes. In practical terms, these findings imply that the electric camera sensor is more suitable for athletes at the national or elite level, whereas virtual reality archery may serve as an effective alternative for beginner-level athletes, offering improvements albeit with relatively lower gains.

Table 6. Independent T-test Results for Archery Accuracy Electric Camera Sensor & Virtual Reality Archery

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Archery Accuracy	Electric Camera Sensor - Virtual Reality Archery	.326	.575	2.181	18	.001	4.400	3.727	-3.430	12.230

Based on the results of the hypothesis, there are significant results in providing fixed distance drilling training using an electric camera sensor that has an impact on the arrow throw which can be measured by the slow motion movement when releasing the arrow. The arrow throw and the rotation of the arrow when released

have their own calculations based on research when the arrow is launched from the bow, the effective rotation in releasing the arrow is 100-120x rotation at a distance of 30-40 meters so that with this accuracy it gives a definite effect when releasing the arrow more than that rotation will give less than maximum results on archery accuracy. Not only the calculation of the rotation of the arrow throw but the movement of the arrow can also be assessed from the results of the electric camera sensor, the unstable movement makes the arrow often deviate from the intended target (Lease, Lim, et al., 2024). Study Lease, Then Sien Phang, et al. (2024) shows that the mechanics of arrow release affect accuracy results, with arrows thrown perpendicular to the target more likely to achieve the best accuracy point. While Jamieson and Wijesundara (2024) with the parabolic movement of the arrow tends to not hit the target, thus causing a decrease in archery accuracy. It can be interpreted that training combined with arrow sensor technology can provide special accuracy for bow settings and increase archery accuracy. This movement is the same as in shooting sports and tennis ball, where the parabolic shooting movement often makes the results of the arrow's accuracy unstable so that the aim at the target needs to be raised to provide maximum results (Yang et al., 2024).

By providing virtual reality archery training, there was a significant increase, marked by an increase in scores in the virtual reality archery group (Li et al., 2024). Virtual training is often underestimated from archery research with virtual does not directly do real archery technique movements but virtual training can create suggestions and confidence in the process of releasing arrows. Often athletes who experience panic targets when releasing arrows cause trauma, this trauma often causes athletes to not dare to release arrows when they see the middle target (yellow) so that with the existence of virtual reality archery training, this can be used as an alternative for archery practice (Priambudi et al., 2023). Virtual reality archery here actually still applies the 10 archery techniques (Prasetyo et al., 2022). In detail, athletes are given a tool to be used on the head which will later be used like wearing glasses, then the athlete holds the tool in the left hand (as a homemade bow) and the right hand pulls the string like pulling a bow. Performing archery technique movements with virtual reality archery has an impact on the psychology of athletes and is used as an exercise that can be used anywhere and supports the mental aspect in real competitions (Jamieson & Wijesundara, 2024). It can be concluded that the existence of technology-based training can be a solution for trainers to create regular training programs by utilizing the latest technology.

Both exercises given gave a significant impact and there was an effect in increasing the accuracy of archery. However, giving exercises by utilizing arrow sensors gave a better impact with a valuemean 323.7 than training with virtual reality archery training with a mean value of 319.3. Training with an electric camera sensor tool is more appropriate for national and elite level archers so that archery evaluation is more accurate and the determination of bow settings/tuning is more precise so that the arrow will not deviate from the target to be aimed at. Supported by research (Tarhan et al., 2024; Yacshie et al., 2022), The tuning method is very effective if supported by supporting tools to improve the suitability of bow tuning. While virtual reality archery training is more suitable for beginner level archers because with virtual beginner athletes do not feel bored with archery training whose character is releasing as many arrows as possible at the target. Beginner archers often feel bored with archery training so it would be suitable if there was modern training and had a positive impact on improving performance and achievement (Decheline et al., 2024; McCalla, 2024). This research is an international collaboration research, of course there are obstacles experienced, namely the distance between Indonesia and Malaysia so that not all the time can control the pattern of rest and activity after exercise which can certainly affect the treatment during the study for 18x.

CONCLUSION

It can be concluded that providing treatment by utilizing developed technology needs to be carried out comprehensively, especially in Indonesia. The innovation of electric camera sensor technology and virtual reality archery has different results where electric camera sensor training is more appropriate for athletes in the national and elite categories, while virtual reality archery is suitable for beginner athletes. So that determining the training program can be much more effective in improving archery accuracy. This research has been carried out in a structured manner, but there are limitations that are experienced, namely when the data collection process is hampered by the distance that is quite far and the lack of control over athlete activities

outside of treatment. So it is necessary to create new and more suitable tools if the process of conducting research is carried out in one environment/training center so that the focus is on conducting research, and can be researched in the future for advances in sports technology.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research.

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