Journal of Physical Education and Sport ® (JPES), Vol. 21 (3), Art 193, pp. 1520 - 1524, May 2021
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Validity of the scoring system technology for detecting points in archery

HIDAYAT HUMAID[1], RAMDAN PELANA[2], WENDY CHIA-SMITH[3], BAGUS WINATA[4], EVA YULIANTI[5], FERRY YOHANNES WATTIMENA[6], ENDRO ARTONO[7]
[1,2,5,6,7]Sports Science Department, Universitas Negeri Jakarta, INDONESIA
[3]School of Education, Loyola University, UNITED STATES
[4]Sports Science Department, Institut Teknologi Bandung, INDONESIA

Published online: May 31, 2021
(Accepted for publication May 15, 2021)
DOI:10.7752/jpes.2021.03193

Abstract:
In amateur and junior level archery competition, judges and trainers manually determine the points earned by archers by either using binoculars or by approaching the target board to observe and validate the position of the arrow. Therefore, the aim of this study is to develop and test the validity and reliability of the scoring system technology (SST) for detecting points automatically. The SST was manufactured by combining several components such as aluminum, microcontroller, light-emitting diode (LED) display monitor, and power supply. Furthermore, after its manufacture, the experimental aspect which involved the archers of various skill levels, which consisted professional (n=5) and amateurs (n=5). They were instructed to shoot three arrows from a distance of 30-meter at the Fédération Internationale de Tir à l'Arc (FITA) target face equipped with SST. The performances were directly reported to the archers through the LED panel. Simultaneously two FITA certified judges observed the shots behind the archers and recorded their performances. Descriptive statistics and ANOVA examined the scores collected from SST and judges observations. The statistical analysis results which were obtained using the one-way ANOVA showed that there was no significant difference ($p = 1.0$) between the points generated by the SST and the Judges. The findings suggest that that SST could provide a valid scoring system for archery competitions.
Key Words: **Automatic, Accurate, Bow, Measurements, Sports Equipment.**

Introduction

Archery is a static sport which is influenced by several factors such as endurance and strength of the upper body, especially of the shoulder girdle (Ertan et al., 2003). Furthermore, several studies have stated it is also influenced by physiological and psychological factors such as heart rate and hemispheric asymmetry response (Landers et al., 1991).

Various experts have divided the shooting process of this sport into several phases of movement (Soylu et al., 2006; Leroyer et al., 1993; Nishizono et al., 1987). Specifically, according to (Leroyer et al., 1993) it is divided into 3, namely stance, arming, and sighting. Meanwhile, some other literacy more specifically divided it into 6 phases, namely bow hold, drawing, full draw, aiming, release, and follow through (Nishizono et al., 1987).

In general, archers always practice to improve their performance through several aspects of training, such as training their level of concentration and balance when shooting and releasing arrows, as well as a few small flexor and extensor muscles in the shoulder, arm, and fingers when drawing, holding and releasing a bowstring (Ertan et al., 2003). Therefore, it is not surprising that many previous studies have always focused on measurements of the physiological and psychological aspects of this sport (Kim et al., 2015), or on determining the correct technique for shooting, to help archers and trainers improve their performance (Cevdet et al., 2011).

In an archery match, each competitor makes the maximum effort to shoot the target, which is represented by colors, such as yellow for 10 and 9 points, red for 8 and 7 points, and blue for 6 and below, 3 times (İpek et al., 2014). Therefore, the winner is determined by the judge by observing and adding the points gained by each archer (İpek et al., 2014). This process of observing and validating the results by the judges, coaches and archers is usually carried out with the help of cameras which have great precision and accuracy, and then the results are displayed on a digital scoring board (İpek et al., 2014). Unfortunately, this equipment is very expensive, usually used only in international competitions, and impractical for most practitioners and scientists.

In a lower scale competition for amateur and junior levels, such as regional, and university events and more, judges, trainers and archers usually only use binoculars or approach the target board, to directly observe and validate where the arrow is stuck, to determine the point obtained (Ertan et al., 2005). Moreover, until presently, this has certainly resulted in several disadvantages, such as time wastage in the observation and validation process, therefore interfering with the concentration of archers and affecting their next performance, or creating the possibility of debate between judges, coaches and players when determining the points obtained (Edelmann et al., 2002).

Corresponding Author: HIDAYAT HUMAID, E-mail: hhumaid@unj.ac.id

Based on these facts and problems, to the best of the author's knowledge, there is no existing research that can test the validity and reliability of a tool which can automatically monitor the shots of archers to determine the scores earned, in the place of judges, coaches, and archers. Therefore, the purpose of this study is to create and test the validity and reliability of scoring system technology (SST) for detecting points in archery automatically. It has the hypothesis that the results shown or given by the SST will not be significantly different from those obtained by a judge.

Material & methods

Participants

A total of 10 male athlete archers, consisting of 5 amateurs of ages 21.80 ± 2.17 years, weight 67.80 ± 2.95 kg, height 1.75 ± 0.06 m, and BMI of 22.28 ± 1.38 kg/m2, and 5 professionals of ages 27.2 ± 2.28 years, weight 70.80 ± 2.77 kg, height 1.77 ± 0.08 m, and BMI of 22.55 ± 1.52 kg/m2 were participants in this study. Moreover, all athletes were recruited based on pre-defined inclusion and exclusion criteria. The inclusion criteria for the professional category are those in the age range of 25 to 30 years, have participated in at least a national scale competition, and carry out a minimum of 15 hours of practice per week. Meanwhile, for the amateur category, they are those within the ages of 20 to 25 years, have never been involved in a professional competition, and carry out a minimum of 10 hours of practice per week. All participants that experienced musculoskeletal injuries within the last 3 months were exempted. The selected archers were then exposed to the SST and how it works 1 week before the commencement of experimental session, in order that they become familiar with it. Finally, all the procedures were approved by the ethics committee of Jakarta State University (372/UN41.14/PR.11/2019), and the experiments were performed in accordance with the Declaration of Helsinki.

Testing setup

The SST can be seen in Figure 1, and it was made by combining several components such as aluminum, microcontroller, light-emitting diode (LED) display monitor, and power supply. Furthermore, due to the concept with which it was manufactured, it uses the "switch" principle, which involves 2 conductors that produce electric current when connected, and vice versa. It also uses 2 aluminum wrought alloys connected to the power supply, as a conducting medium. In the principle of implementation, when the alloys are connected due to a prick by the iron arrowhead, which acts as a conductor, they will give a sensor response to the microcontroller, which is then converted using a programming language to a point number for archers. More specifically, the two components of the alloy which has been assembled according to the circular pattern of the target will be separated by each of the two target papers in the installation process. This is shown in the highlights of Figure 1.

The aluminum wrought alloy was connected to the CAL 60 IPA STD power supply with a set of NYMHYO electrical cables and then to the aluminum sensor as a source of power. While the microcontroller (IC Microcontroller AT89C51) was programmed in C ++ language to detect the position where the arrow strikes the aluminum sensor, and convert it to the point obtained, which is then displayed by a LED panel as the results. In the design process, the whole apparatus could be built or obtained for less than US $400, therefore it is very economical for judges, coaches and archers to buy and use to support the smooth running of matches or training processes.

Experimental overview

Anthropometric measurement sessions were carried out as the initial measurement in this study, and were conducted when the subjects were barefooted and putting on minimal clothes. The sessions involved using an Omron HBF-375 Karada Scan Body Composition Scale to assess the body weight and fat percentage of all participants, and a Seca 214 Portable Stadiometer with 0.1-cm readability to measure their heights. In addition, it involved calculating their body mass index, which was carried out by finding the ratio of their body mass (kilograms) and height (meters) squared. After the anthropometric measurements were completed, all participants proceeded to the experimental session, where each of them shot 3 arrows at a distance of 30-m indoors at the SST, which was designed as an official FITA target face. However, before the shooting, they were required to warm up statically for at least 10 minutes.

A Sony Handycam FDR-AX53 handycam camera with a resolution of 1280x720 - HD, 20 x optical zoom and 250 x digital zoom was installed to assist the judges in reviewing the results of the shots. Furthermore, it was mounted on a 3m high tripod at a distance of 5m behind the archers, and its lens was focused on the SST target face.

2 Judges, selected based on 2 criteria, namely: (1) have obtained a judge license from FITA, (2) have at least 5 years' experience as a judge in a national or international scale competition, were assigned to validate the results of the video against the points obtained by the shots of the archers. Meanwhile, they carried out the assessment and validation based on the rules set by FITA, namely: yellow equals 10 and 9 points, red, 8 and 7 points, blue, 6 and 5, black, 4 and 3, and white, 2 and 1. Finally, 2 blind administrators were assigned to take reports of the points obtained by the SST and judges. The experimental design can be seen in Figure 2.

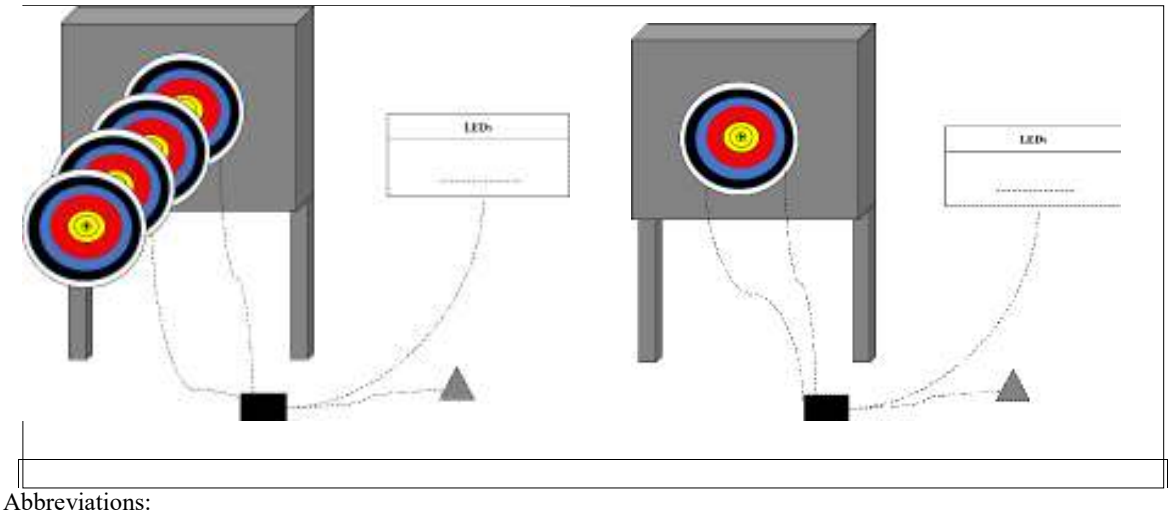
Archery shots

All archers stood at the shot point and commenced the shooting process, which encompassed several stages, such as bow hold, drawing, full draw, aiming, release, and follow through. Moreover, they were given the opportunity to shoot 3 times. After an archer finished a session, a period of 5 minutes was given before the next archer commenced shooting. The judges were positioned behind the archers, and they reviewed or validated the results of the shots through the video displayed by the camera.

Data collection and analysis / Statistical analysis

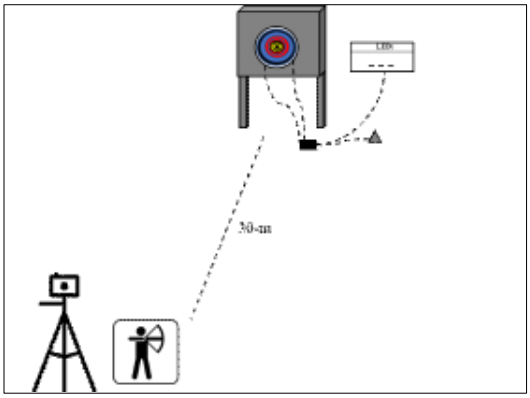
The values were presented as mean ± SD, and a one-way ANOVA test was used to determine the significance of the points shown by the SST and the validation observations provided by the two judges. Statistical significance was accepted at the $p < 0.05$ level, and the tests were performed using the SPSS software V.21.0.

Figure 1. The SST for detecting point in archery



Abbreviations:
Point 1: Geologic target paper
Point 2: Aluminium wrought alloy target
Point 3: Geologic target paper
Point 4: Aluminium wrought alloy target
Point 5: Target board
Point 6: NYMHYO cable
Point 7: Power supply (CAL 60 IPA STD)
Point 8: Microcontroller (IC Microcontroller AT89C51)
Point 9: LEDs

Figure 2. Experimental position during validity of SST



Abbreviations:
A: Archers
B: The SST
C: Camera

Results

Tables 1 and 2 show the comparison between the statistical results obtained based on the points generated by the SST and the judges. More specifically, ANOVA showed that there was no significant difference ($p = 1.0$) between the points with respect to the five professional archers. Similar results were shown in the measurements with regards to the amateur, and ANOVA showed that there was no significant difference between the points.

Table. 1 Comparison of the point results generated by SST and judge reviews on professional archers
Abbreviations: The values are presented as mean ± SD SST – Scoring System Technology

Table. 2 Comparison of the point results generated by SST and judge reviews on amateur archers
Abbreviations: The values are presented as mean ± SD SST – Scoring System Technology

Discussion

In line with the hypothesis, this study was successful in showing that the point results generated by the SST were not significantly different from the scoring results manually validated by the judges. In other words, the device has been shown to be able to detect points earned by archers automatically. To the best of the author's knowledge, this is the first study concerned with the manufacture and validation of archery equipment, to help archers, judges and trainers detect points generated by the shots of archers automatically.

In the world of sports, a lot of automatic equipment is used to help referees or other competition officials minimize the risk of human error when making decisions (Haugen et al., 2016). Notwithstanding, it is also not uncommon for this equipment to be used by athletes and trainers for talent screening and to support the training and development process of athletes. For example, (Syahruddin et al., 2019) developed an infrared sensor technology (IST) test as a tool for assessing flexibility. Furthermore, they stated that evaluating flexibility is important to coaches to assess their players' flexibility status, predict future performance, and even detect those that are talented. They also stated that coaches and athletes to date have only used rulers in the measurement of the anterior superior iliac spine (ASIS) from mattresses, and this gives room for human error. Due to these interests and problems, their research succeeded in making IST as an automatic equipment for measuring the distances of the ASIS from mattresses.

Although it is difficult to compare SST with other automatic sport equipment in archery, this study still supported the previous research conducted by (Syahruddin et al., 2019) on the development of an automatic sport equipment, which aimed to help judges, referees, competition officials, athletes, and coaches minimize the risk of human error when making decisions during competitions or in training processes to develop the potentials of athletes

Initial name	Parameters measurements	Trial 1 (point)	Trial 2 (point)	Trial 3 (point)	($\bar{x} \pm SD$)	*p*-value
BW	SST	9	9	8	8.7 ± 0.6	1.0
	Judge	9	9	8	8.7 ± 0.6	
DAS	SST	9	8	8	8.3 ± 0.6	1.0
	Judge	9	8	8	8.3 ± 0.6	
RFS	SST	9	9	7	8.3 ± 1.2	1.0
	Judge	9	9	7	8.3 ± 1.2	
MI	SST	9	9	8	8.7 ± 0.6	1.0
	Judge	9	9	8	8.7 ± 0.6	
NO	SST	9	8	9	8.7 ± 0.6	1.0
	Judge	9	8	9	8.7 ± 0.6	

More specifically, it also supports the study by Cave et al. which states that technology in sports can help all levels of sports practitioners and even those with disabilities to support the progress and development of athletes.

Initial name	Parameters measurements	Trial 1 (point)	Trial 2 (point)	Trial 3 (point)	($\bar{x} \pm SD$)	*p*-value
RW	SST	8	7	6	7.0 ± 1.0	1.0
	Judge	8	7	6	7.0 ± 1.0	
RB	SST	7	8	8	7.7 ± 0.6	1.0
	Judge	8	7	6	7.7 ± 0.6	
SS	SST	9	6	7	7.3 ± 1.5	1.0
	Judge	8	7	6	7.3 ± 1.5	
KAS	SST	8	8	9	8.3 ± 0.6	1.0
	Judge	8	7	6	8.3 ± 0.6	
MRS	SST	6	5	7	6.0 ± 1.0	1.0
	Judge	8	7	6	6.0 ± 1.0	

Apart from showing the comparison between the accuracy of the results generated by the SST and the judges, this study also succeeded in proving that this device could accurately distinguish between the results of shots taken by professionals and amateur archers. This can be seen from the results which showed that professionals tended to have better accuracy in making shots in all trials, with an average point of 8.7 ± 0.46 compared to amateurs, as they only had average point of 7.3 ± 1.16. Furthermore, apart from showing the success of SST validity and reliability, it also supports the study by (İpek et al., 2014) which stated that professional archers tend to shoot closer to the yellow ring.

The results are expected to help judges and archers, especially those in the amateur or junior category, read the points generated by each shot automatically. The drawback observed in this study was the long time spent in assembling the SST tool. However, this does not reduce the usefulness of the tool, as tests show that it is valid and reliable. Also, it is very affordable, and can easily be obtained by any group in the amateur category. Therefore, this study encourages every judge, archers or trainer to use SST as an automatic sport equipment to help them observe and validate the results of shots in archery. It also provides an opportunity for future research to perfect this tool, to make it more portable and easier to assemble.

Conclusion

The results confirm that SST is a valid and reliable tool for automatically detecting points in archery. Therefore, it can be used by athletes, judges, and coaches to observe and validate scores automatically.

Conflicts of interest All authors state no conflict of interest.

References:

Cevdet. T. (2011). Shooting dynamics in archery: A multidimensional analysis from drawing to releasing in male archers. Procedia Engineering, 13, 290-296.

Edelmann, N.J., Gruber, M., & Gollhofer. (2002). Measurement of on-target-trajectories in Olympic archery. In: Haake SJ, editor. The engineering of sport Blackwell Science, 487-93.

Ertan, H., Kentel, B., Tumer, S. T., & Korkusuz, F. (2003). Activation patterns in forearm muscles during archery shooting. Human Movement Science, 22, 37–45. doi: 10.1016/s0167-9457(02)00176-8

Ertan, H., Soylu, A. R, Korkusuz, F. (2005). Quantification the relationship between FITA scores and EMG skill indexes in archery. J Electromyogr Kinesiol, 15(2), 222-227. doi: 10.1016/j.jelekin.2004.08.004

Haugen, T., Buchheit, M. (2016). Sprint Running Performance Monitoring: Methodological and Practical Considerations. Sports Med, 46(5), 641-56. doi: 10.1007/s40279-015-0446-0

İpek, E. K., Murat, C., Hayri, E. J, & Axel, K. (2014). Assessment of Target Performance in Archery. Procedia - Social and Behavioral Sciences, 152, 451-456.

Kim, H. B., Kim, S.H., &So, W. Y. (2015). The relative importance of performance factors in Korean archery. J Strength Cond Res, 29(5), 1211-1219. doi: 10.1519/JSC.0000000000000687

Landers, D. M., Petruzello, S. J., & Salazar, D. J. (1991). The influence of Electrocortical Biofeedback on Performance in Pre-elite Archers. Medicine and Science in Sports and Exercise, 23(1), 123-129.

Leroyer, P., Hoecke, V., & Helal, N. (1993). Biomechanical study of the final push–pull in archery. Journal of Sports Sciences, 1, 63–69. doi: 10.1080/02640419308729965

Nishizono, H., Shibayama, H., Izuta, T., Saito, K. (1987). Analysis of archery shooting techniques by means of electromyography. International society of biomechanics in sports. Proceedings Symposium, V 365–371.

Soylu, A. R., Ertan, H., & Korkusuz, F. (2006). Archery performance level and repeatability of event-related EMG. Hum Mov Sci, 25(6), 767-74. doi: 10.1016/j.humov.2006.05.002

Syahruddin, S., Imam, I. S, Lungit, L., Ramdan, R. P., & Bagus, B. W. (2019). Infrared Sensor Technology (IST) Test as a Tool for Assessment of Flexibility. Advances in Rehabilitation, 33(3), 5-9. https://doi.org/10.5114/areh.2019.87743