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RESEARCH ARTICLE

Developing a Foul Detection Application for the Sepak Takraw Game: Construct Validity and Inter-rater Reliability

Putri Prastiwi Wulandari[1*], Siswantoyo[1], Panggung Sutapa[1], Dewangga Yudhistira[2]

[1]Faculty of Sport Science, Universitas Negeri Yogyakarta, Indonesia
[2]Faculty of Sport Science and Health, Universitas Negeri Surabaya

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***Corresponding Author:**
putriprastiwi.2020@student.uny.ac.id

ABSTRACT

Decision-making is still often seen as subjective. This is because the referee's position is on the sidelines and visual observation is limited. Providing solutions requires special attention. The purpose of this research is to develop a violation detection application for the Sepak Takraw game. The developmental research method uses a 'define, design, develop' approach. The participants consisted of five experts, including a nationally qualified referee, a media expert with a doctorate in engineering, a nationally qualified coach, and two academics specializing in sepak takraw. Data were analyzed using Aiken's formula, Cronbach alpha reliability, and intraclass correlation coefficient (ICC). In the definition step (1), the authors defined, formulated, and analyzed the requirements to develop a foul detection tool known as Jury Service Takraw (JST). In the design stage (2), the authors design the application by customizing the requirements needed to build and design the JST. In the development stage (3), we developed the actual JST application, assembled the JST tool, and simultaneously built a 1-5 scale tool to evaluate the application. The authors then evaluated the application by five experts using the Delphi method until a consensus was reached. Results showed content validity scores of 0.75 to 1.00, Cronbach's alpha reliability of 0.902, ICC mean agreement of 0.909, and single rater agreement of 0.667. The JST application was shown to have high content validity, high Cronbach alpha reliability, and strong and consistent mean agreement. The JST application aims to facilitate referees in determining violations in sepak takraw matches.

INTRODUCTION

A foul in sepak takraw occurs when the service makes contact with the net (Sahat & Johari, 2024) A foul occurs when the tekong's support foot is outside the circle line when serving and seems to be in a jumping position. A foul at the net happens when the athlete's body or clothes contacts the net, pass through it, and crosses the line beneath it (Potisaen & Potisaen, 2022) If a foul happens during the match, the referee must pay close attention. Mistakes in decision-making regarding fouls are caused by limited observation by the referee (Zarei et al., 2018).

Aside from that, referees frequently differ in their perceptions of foul rulings in serving and fouls in the net, particularly team numbers (Zonouz et al., 2014) This is due to (1) the referee's position on the edge of the field's center line, (2) the coach's position behind the service line, and (3) the server's position in the center of the service circle (Zhang & Byon, 2017). Certainly, this is especially important when making decisions to deliver objective results.

The authors conducted interviews with trainers to gather information in the field. Coach (1) added, *"Athletes and coaches question the referee's decision to serve team numbers because there is no technology to prove that a violation occurred." When serving, the server cannot see the circle line below him since he is concentrating on the ball about to be kicked, and the service is very rapid". Coach (2) Almost all of the referees at the sepak takraw event in Bandung refused to officiate the match due to widespread objections from both coaches and athletes against the referee's foul decision*, This is thus a special concern in decision-making to get objective results.

When foul decisions are formed by observation, the results are less objective. The effort is made to use technological tools. Technology for observing fouls in other sports does exist, such as instant playback systems with high-speed cameras positioned at field sites, also known as eagle eyes (Dwi Yulianto et al., n.d.). This technology employs software with three-dimensional modeling to produce images from the camera to the computer (Shui, 2023).

Eagle eye technology is regarded as an essential decision-making component, giving tools for coaches, athletes, and statisticians to do game analysis (Abbas et al., n.d.) Eagle eye technology is also used in cricket to track the trajectory of the ball and make choices on the field, using cameras and systems analyzing the speed and position of the ball (Penjaskesrek et al., 2014). Other significant research is the use of video assistant referees (VAR), which was employed during the 2018 FIFA World Cup and the 2022 European Football Championship (Mamu et al., 2022). Furthermore, video reconstruction is being developed to observe the movements and flow of competition in karate (Muhyi et al., 2021).

According to qualitative analysis conducted through interviews, there are still anomalies in referee decision-making. This can be noticed when many referees in sepak takraw make different decisions. Aside from that, subjectivity is strong because observations still rely on the

referee's visual perception. Aside from that, technological advancements are also important. Based on document analysis in the form of various relevant publications, the development of foul detection technologies has evolved, including video assistant referee (VAR), eagle eye foul detection, and video reconstruction for motion analysis. However, this development remains mostly concentrated on football, cricket, tennis, table tennis, and karate. Technological advancement has received little attention in the sport of takraw. In this regard, the authors will offer a solution by developing a foul detection application in sepak takraw called jury service takraw (JST) and filling gaps in past research. However, in the early stages of product development, it is vital to assess the validity and dependability of a constructed design (Muin et al., 2023). The purpose of this study thus is to assess the content validity and inter-rater reliability of the Juri Service Takraw (JST) foul detection tool.

METHOD

This is a development study that involves defining, designing, and developing a three-dimensional (3D) design. This study was conducted until the development stage because the authors did not intend to assess the efficacy of the product being created. This study employed both qualitative and quantitative methods. The research stages are as follows:

Defining stage

At this point, the authors begin to identify and formulate the problem as a condition for rationalizing the problem to design a foul detection tool in the sport of sepak takraw known as Jury Service Takraw (JST). This is a very early stage before beginning the construction design of the foul detection tool. This stage consists of (a) Analysis of initial findings, namely determining basic problems such as the phenomenon of referee observations to make subjective foul decisions, and observations through document analysis in the form of relevant articles that the development of foul tools in the sepak takraw sport has yet to receive special attention, (b) concept analysis, at this stage, the authors have developed a concept as a line of thought and a framework to aid in the design process. (c) determine instructional objectives, which refers to the formulation of development objectives to assist referees in implementing sepak takraw matches, particularly the objective determination of fouls.

Designing Stage

Development, a foul detection tool known as jury service takraw (JST). This stage is divided into three stages: (1) picking relevant tools to develop the tool, (2) organizing construction in a practical and minimalist design, and (3) generating an initial JST design. The initial design resulted in the construction or prototype of a JST tool for detecting fouls.

Developing Stage

At this stage, the authors have finished real development by combining JST products and conducting expert

assessments, resulting in a product that is ready for evaluation. At this stage, (1) the authors prepared tools based on predetermined steps, then at the same time as preparing the tool, the authors created a 1-5 Likert scale questionnaire as an assessment sheet for experts, (2) The authors then evaluated the JST tool using a questionnaire created using the Delphi technique, which entailed meeting with material and media specialists separately. There are five experts: one nationally certified referee, one media expert with a doctorate in engineering, one nationally licensed takraw trainer, and two material experts with a PhD in sports science with a focus on sepak takraw. (3) After getting assessments from five experts until consensus was established, the authors conducted a qualitative analysis, specifically interpreting the expert viewpoint. The quantitative analysis was collected from an expert assessment using a Likert scale of 1-5, with Aiken analysis used to evaluate content validity. After determining the content validity results, the authors assessed the reliability of Cronbach alpha and Intraclass Correlation Coefficient (ICC) to ensure expert agreement (ANDRIANTO, 2023). The data was analyzed using Excel and the SPSS version 23 programs. Aiken's content validity formula is given below:

$V = \sum s / [n (C-1)]$
S = r – lo Lo = lowest value
C = highest score
R = expert assessment figures

RESULT

In the results and discussion section, the authors describe the results of (1) content validity analysis with Aiken (2) Cronbach alpha and Intraclass Correlation Coefficient reliability analysis, and (3) the construction/prototype and required tools. The analysis findings are reported below:

Aiken Validity Results

Tabel 1. Content validity results using the aiken formula

Question	Assessor					s= r - lo					Σ	n* (c - 1)	V=S/(n *(c-1))	Decision
	1	2	3	4	5	1	2	3	4	5				
1	4	5	5	5	5	3	4	4	4	4	19	20	0,95	Valid
2	4	4	4	4	4	3	3	3	3	3	15	20	0,75	Valid
3	4	4	4	4	4	3	3	3	3	3	15	20	0,75	Valid
4	4	4	4	4	4	3	3	3	3	3	15	20	0,75	Valid
5	5	4	4	4	4	4	3	3	3	3	16	20	0,80	Valid
6	4	4	4	4	5	3	3	3	3	4	16	20	0,80	Valid
7	4	4	4	4	4	3	3	3	3	3	15	20	0,75	Valid
8	5	5	5	4	4	4	4	4	4	4	20	20	1.00	Valid
9	4	4	4	4	4	3	3	3	3	3	15	20	0,75	Valid

Based on the assessment of 5 item material experts, (1) the JST application was produced in line with the circumstances in the field that require a foul detection application in sepak takraw matches and obtained a score of 0.95; (2) the application developed is based on modern technology and received a score of 0.75, (3) the material requirements are in accordance with the objectives for developing applications and obtained a score of 0.75, (4) The application can provide video analysis, colors, and fonts well and received a score of 0.75, (5) the placement of the application is appropriate in a sepak takraw match gets a score of 0.80, (6) the application can provide solutions within limited previously problems and got a score of 0.80, (7) the tool developed had a medium size so it was easy to use and obtained a score of 0.75 (8) the tool developed was practical in operation and got a score of 1.00, (9) the tool developed had a good level of security, got a score of 0.75. Based on the data that has been described, the overall value ranges from 0.75-1.00, which means that it has a good level of content validity.

Cronbach Alpha and Intraclass Correlation Coefficient reliability results

Table 2. cronbach alpha reliability results

Cronbach's Alpha	N	Decision
.902	5	Reliable

The Cronbach alpha reliability test yielded a result of 0.902. The findings of this research reveal an average agreement of 0.902, indicating strong reliability. As a result, the Jury Service Test (JST) application has an excellent quality and stability agreement.

Table 3. Intraclass correlation coefficient reliability results

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.667[a]	.389	.893	10.231	8	32	.000
Average Measures	.909[c]	.761	.977	10.231	8	32	.000

According to the interclass correlation coefficient reliability test, the average agreement between raters is 0.909, whereas one rater's consistency is 0.667. As a result, it can be explained that the agreement among raters is very solid, and each rater has good consistency.

Suggestions based on the results of expert assessments

» The tool's design is good. The tool's term should be more scientific in nature, particularly in the field of sepak takraw. Please add an indicator in the form of a light (light) to tools so that referees, players, and spectators can see them clearly on the field. Please add some form of cooling to the detecting tool so that it works consistently. Light settings are required so that the instrument may be easily used and adjusted whether indoors or outside. The developed tool is safe for use.

»The tool created can assist the referee's duties during the match. To shield the detector from heat and rain, an additional umbrella or protection is required at the top, and the tool's name must be paid attention to.

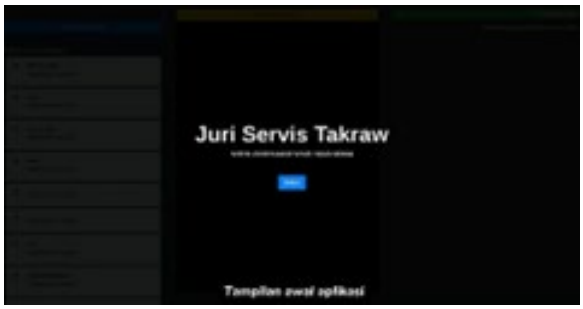
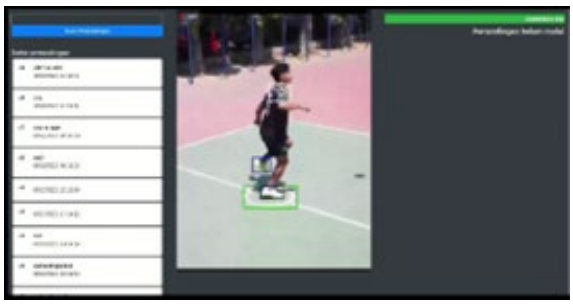
» The tool's name is determined by the maker's initials. The tools produced are of high quality and can be utilized during training, particularly for servers, as well as during matches. In the future, it is envisaged that the most advanced tools and technology will be used primarily in the sport of sepak takraw. Future plans must be created for massing the equipment.

»The tool that has been developed is very good. This Service Foul Detection tool needs to be socialized, particularly to players in the sepak takraw sport, and officials and coaches need to be educated about the availability of a foul detection tool, specifically for serves.

Tabel 3. Hardware

Figure	Information
 **Fig. 1 Display of the takraw jury service application**	View of jury service takraw
 **Fig. 2 Raspberry Pi V3 camera**	» Sony IMX708 sensor » The diagonal optical size of the sensor is 7.4 mm » Sensor resolution 11.9 megapixels » Max resolution 4608 x 2592 pixels » Video modes 1080p50, 720p100, 480p120 » Phase detection auto-focus system » Focus range 10 cm » Focal length 4.74 mm » Dimensions 25 x 23.9 x 115 mm
 Fig. 3 Jetson Orin Mini PC	» 12v/5A power supply » Jetson orin nano module » 20 TOPS AI performance »CPU 6-core ARM Cortex-A78AE v8.2 6bit » CPU mac frequency 1.5GHz » NVIDIA 512-core max GPU » GPU max frequency 625MHz » 4GB 64bit LPDDR5 memory » 128GB NVMe SSD storage »Dimensions 130 x 120 x 58.5 mm
 Fig. 4 Philips LED	» As a light indicator when a foul occurs »50 watts » True force core LED » E27 base cap » 50,000 switch cycles »Nominal service life 15,000 hours

Tabel 4. Software

Figure	Information
 **Fig. 5 The initial appearance of the application**	» When the tool is used, there will be a blue icon on the application display that says the command "start". Once ready, click the “start” command.
 **Fig. 6 Next application display**	» Click "start live video" in the yellow text to start showing the video live.
 **Fig. 7 Video of the judging process**	» Next, to carry out the judging process, press the "start service" button in yellow, after that, the application will carry out foul detection.
 **Fig. 8 Application appearance when live**	» Next, press the “click match” button on the blue icon so that the application will record a video to detect fouls

DISCUSSION

The goal of this study is to develop a jury service takraw (JST) tool for foul detection in sepak takraw matches, specifically when a foul occurs in the service technique. Of course, similar applications already exist, such as video review analysis and eagle eye recognition capabilities for tennis and table tennis. However, sports development continues to receive little attention, thus the jury service takraw (JST) application is rather unique. This application development stage consists of three stages: define, design, and develop. In the define stage, the authors establish the concept and choose a name; in the design stage, the authors begin designing the JST product using a thorough needs analysis; and in the development stage, the authors evaluate the product design for the jury service takraw (JST) application.

According to five experts, the jury service takraw (JST) application has good content validity, with values ranging from 0.75 to 1.00. According to past studies, the content validity level between 0.80 to 10.00 has high content validity (Hendryadi, 2017; Yudhistira & Tomoliyus, 2020; Yulianto & Yudhistira, 2021). According to Aiken's analysis, the jury service Takraw app has a high level of content validity. The reliability of each part of the jury service takraw (JST) application was then assessed using Cronbach alpha. The Cronbach alpha analysis yielded 0.902. This indicates that certain aspects of the Takraw jury service application's material can be considered as highly reliable. Other research has validated the minimum Cronbach alpha value of 0.70. If the Cronbach alpha score is > 0.70, the content features of the instrument can be considered reliable(Tomoliyus & Sunardianta, 2020).

To measure inter-rater reliability and consistency, each assessor applies the interclass correlation coefficients (ICC) formula. The rationale for utilizing ICC is that there are more than two assessors, hence it requires further testing. The ICC analysis revealed that the average agreement between raters is 0.909, whereas one assessor's consistency is 0.667. According to the study, the value of the agreement category between raters is greater than 0.75, indicating very good agreement; 0.40-0.75 indicates good agreement; and an ICC value greater than 0.75 is considered very good (Tomoliyus & Sunardianta, 2020). As a result, the ICC findings are above this category, implying that the agreement between raters is quite robust and each rater is quite consistent.

Some foul detection technologies or tools in sports have been useful in improving accuracy, such as In rugby, GPS systems have been used to monitor the workload of the players, by introducing individual speed thresholds in training, leading to a decrease in the likelihood of injury (Aoki et al., 2017; Aroganam et al., 2019; Bădescu et al., 2022). Hawk-Eye, which has been used in tennis since 2006, tracks the trajectory of the ball and assesses whether it enters or leaves the court. found that the Hawk-Eye, which has been used in tennis since 2006 to track the trajectory of the ball and assess whether it is entering or leaving the court (Li & Shi, 2014). In team ball sports, Virtual Reality (VR) is used as a tool for simulation, analysis, and training. This technology gives researchers the ability to control and standardize training situations. Limitations and shortcomings related to technical issues or the way the research was designed (Bădescu et al., 2022; Faure et al., 2020; Kupperman & Hertel, 2020). There is likely a variant of data analysis, which follows athletes' eye movements, in virtual reality systems. Devices such as sensors in players' shoes or clothing measure physical performance, such as speed, acceleration, and heart rate (Seçkin et al., 2023). Thus, data on the perception and processing of visual information are determined, which determines, for example, in the decision-making capacity of the goalkeeper(Vaeyens et al., 2007).

Furthermore, the camera-based quantum particle swarm optimization calibration system has the advantages of fast response and high assessment accuracy, making it suitable for high-level gaming (Feng, 2017). Other sports, such as football, use goal-line technology (GLT), which determines whether the ball has completely crossed the goal line (Feng, 2017; Winand & Fergusson, 2018). According to research conducted by (Schwab et al., 2023), GLT enhances decision-making accuracy when judging whether a goal was scored. As a result, the progressive presence of video tools in refereeing formations in the 1980s, followed by communication systems between the primary referee and his helpers in the mid-1990s, were forerunners of significant novelties that were later implemented (Joly & Desfontaine, 2022). Modern soccer balls are equipped with RFID (Radio-Frequency Identification) chips that can communicate with devices around the field. This chip helps in tracking the position of the ball with high accuracy, which is very useful for VAR (Video Assistant Referee) systems and automatic refereeing decisions. The chip also allows for more detailed tracking of statistics during matches (Qowiy et al., 2024). The introduction of digital technology such as Goal Line Technology (GLT), RFID (Radio-Frequency Identification) and, Video Assistant Referee (VAR) has significantly altered refereeing activities (Joly & Desfontaine, 2022).

Sepak takraw, a traditional Southeast Asian sport that combines football and volleyball, is seeing exciting improvements because of the availability of fair play technology. This technology, such as the JST under investigation, has enormous potential to increase the accuracy of referee decisions and enable fairer matches. JST technology is presented as a possible solution to the referee's limited vision. This system employs visual analysis technologies to make more accurate and objective conclusions regarding service problems. The research findings demonstrating the "eagle eye"s high validity, as previously noted, strengthen its ability to achieve fair play.

The presence of JST technology can influence the philosophy and culture of the sepak takraw game. Sepak takraw is a sport that depends on the skill, sportsmanship, and ability of referees to officiate matches. JST technology does not necessarily eliminate the role of referees. Referees in this case still have a crucial role in directing matches, preserving sportsmanship among players, and making decisions in gray areas that technology may not handle. It is expected that fair play technology, such as JST, will usher sepak takraw into a new era of fairness and competition. To keep sepak takraw a popular sport in the future, it's important to maintain qualities such as sportsmanship, player expertise, and referee leadership that adapt to technological advancements.

CONCLUSION

Based on the results and discussion, the jury service takraw application has good content validity. The content aspects of the jury service takraw application have a reliable level of reliability. Then the inter-rater reliability test, interclass correlation coefficients (ICC), has very strong agreement between raters, and the raters have quite good consistency. Therefore, the presence of the takraw jury service application can help sportsmanship in running matches but still does not eliminate the role of the referee. It is hoped that technology such as jury service takarw can bring sepak takraw into a new era, which is more competitive, effective, and efficient.

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