

Sensor-based badminton footwork test instrument: A design and validity

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Abstract:

Footwork is a foot movement that brings the body to get the proper position so that it is easy to anticipate the blow and placement of the cock into the opponent's field. In its implementation, athletes are required to be able to move agile, agile and fast without losing balance and good coordination of movements to return the cock with good technique. The better the quality of footwork, the better the athlete's performance in the field. The current footwork test instrument is still manual and inefficient. To prevent human error, it is highly recommended to use digital devices. However, the current digital device has not been able to describe the characteristics and definition of the footwork due to the use of tools (rackets) and field distances that do not follow the actual situation. Therefore, it is necessary to develop the right instrument for measuring digital-based badminton footwork skills so that the data obtained is valid and reliable. This type of research uses the RnD method with the Borg and Gall development model. Instrument design is based on needs analysis, brainstorming with practitioners, and improvements from previous footwork instruments developed and improved according to actual conditions in the field by adding special sensors designed to collect data digitally and accurately. The device was validated using expert judgment techniques involving measurement and evaluation test experts, sensor / IT experts, and badminton experts. The results of this study concluded that this test instrument is valid / very feasible to use to measure badminton footwork skills.

Keywords: Test instrument, Footwork, Badminton, Sensor-based

Introduction

Basic technique is a primary requirement for a badminton athlete to achieve the highest achievement. BWF has four basic techniques for playing badminton, namely standing (stance), holding a racket (grip) (Prajongjai et al, 2023), hitting the ball (strokes) and footwork (BWF, 2017). Footwork technique in badminton is essential (Asriani et al, 2020)(Nandika et al, 2017)(Yogi et al, 2022) because, in a badminton game, the player must move here and there to reach the cock, then position the body in the correct position so that the body is ready when hitting a shot and immediately return to the centre position (Arnando et al, 2021).

The basic principle of footwork in badminton is that the foot that matches the hand holding the racket when hitting the cock always ends up in the direction of the hand (Sapta Kunta et al, 2012). In essence, footwork is the principal capital to be able to hit the cock appropriately. Light and flexible footwork will make it easier for someone to move towards the coming cock with harmonious foot movements and prepare to hit without losing balance. Therefore, badminton athletes must possess good footwork techniques.

To optimise footwork well in every movement is undoubtedly supported by good physical conditions. When we observe badminton matches, athletes usually need a certain amount of strength, speed, agility, endurance and good coordination. (Z.A et al 2016).

Based on this, in good physical conditions, athletes will be able to do good footwork to help badminton athletes move here and there by using footwork, aiming for athletes to be able to act quickly in the face of every attack and reply to the right blow towards the opponent's field (Arnando, 2018).

Therefore, the ability of the athlete's physical condition and footwork efficiency in playing can affect the athlete's appearance in the area. Based on observations and brainstorming between researchers, coaches and badminton athletes in West Sumatra, a tool is needed that can be used to measure the footwork abilities of badminton athletes. And it can also be used as a benchmark in implementing badminton sports performance development, especially in West Sumatra. The following is the implementation of footwork with the concept of 8 cardinal directions.

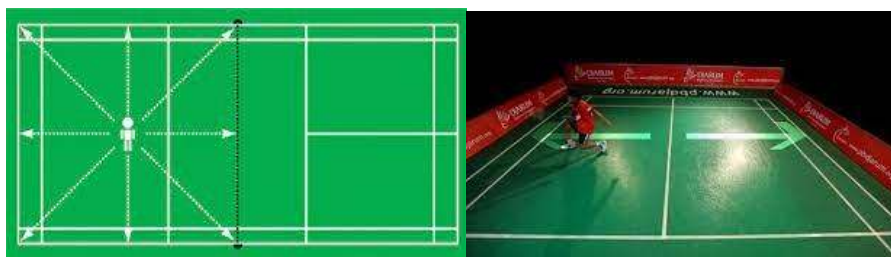


Figure 1. The 8-way concept.

Good footwork enables players to move efficiently to all parts of the field. To improve footwork, a proper training program is needed. The right training program is compiled based on the data obtained from a measurement. To get good data, the correct test instrument is required to measure the ability of digital-based badminton footwork. Digital tools have an essential role in measurement in sports (Prabowo, 2020) because, with digital technology, measurements can be made effectively and efficiently. In terms of measurement, validity and reliability significantly affect data quality. So that the data can represent the actual characteristics and definition of footwork. However, some existing tests still cannot describe the exact footwork characteristics (field and racket), and digital tests cannot be carried out effectively and efficiently in their implementation. In a study, data collection tools (instruments) determine the quality of the data collected, and the quality of the data determines the quality of the research (Nurhasan, 2014)(Taherdoost, 2016). Data must be collected using instruments tested for validity and reliability (Nurul et al, 2017). One that can be utilised is the instrument by using a touch of technology (Nurul et al, 2018). Based on this, the problem formulated in this study is how an excellent digital-based badminton footwork instrument has validity, reliability, practicality, and norms that can be used in digital-based badminton footwork measurements.

So far, the test instrument to measure badminton footwork is still manual (stopwatch). There are still many uses for humans as test officers, so there is a high probability of human error. Furthermore, existing tests only measure agility and reaction, so in their implementation, they often ignore the characteristics of playing badminton by reducing the distance of the field and not using the actual tool (racket)(Arnando, 2018), so footwork techniques are not described by definition in badminton games. Based on this, other elements still have not been appropriately observed. Therefore, it is necessary to develop a digital-based badminton footwork measurement instrument.

Digital technology can accommodate these interests, namely, using software in the instruments used (Ihsan et al, 2021). The digital tool is a sensor that will be developed in this research. Generally, a sensor is a device capable of capturing physical or chemical phenomena and then converting them into electrical signals, either electric current or voltage (Pramusinto et al, 2016). Physical phenomena that stimulate sensors to produce electrical signals include temperature, pressure, force, magnetism, etc (Kurniawan, 2016). The fundamental function of a sensor is to selectively identify and measure physical, chemical or biological parameters, such as pressure, light intensity, gas concentration or the presence and concentration of biological analytes. The basic building blocks of a sensor include one or more transducers (operating in series or parallel) directly leading to the measured quantity, signal acquisition and conditioning electronics, power source, processor, storage media and display (Chiu et al, 2020). Based on the sensor's definition, essential functions, and advantages, the sensor can be utilised to develop a badminton footwork instrument. This is following the characteristics of footwork needed in badminton. The main objective of this research is to produce a valid and reliable sensor-based digital footwork test instrument. With this product, coaches can use this research product as a tool to help measure their athletes' footwork abilities accurately. Apart from that, this tool can also be used by athletes as supporting equipment to optimize footwork training. This product was designed by prioritizing the relevance of implementation regarding the effectiveness and efficiency of movements in badminton

Material & methods

This research was conducted with Research and Development, which is a research method used to produce specific products and test the effectiveness of these products (Rifki et al., 2022). Three things need to be considered carefully in R&D research, namely the level of product validity, product practicality, and product effectiveness (Sahri et al, 2020) (Ihsan et al, 2018). This research will adopt 10 development steps according to Borg and Gall, the stages are as follows: Research with the Borg and Gall development model (R&D) which is modified to be simpler, namely: (1) Conducting research and collecting information data by providing a needs analysis instrument to west sumatra badminton athletes; (2) Making an initial product design for badminton footwork test instruments using various electronic components; (3) The product design that has been designed is then validated by the validator to correct errors and weaknesses; (4) first product revision; (5) small group trial; (6) second product revision; (7) field trial (large group) by testing the results of the second product revision; (8) final product revision (if there is input or suggestions from and field trial); (9) final product development results; (10) publication of articles (products) in journals; (8) final product

revision (if there is input or suggestions from and field trial); (9) final product development results; (10) publication of articles (products) in journals (Sugiyono, 2017). The series of research implementations can be seen in the following flowchart:

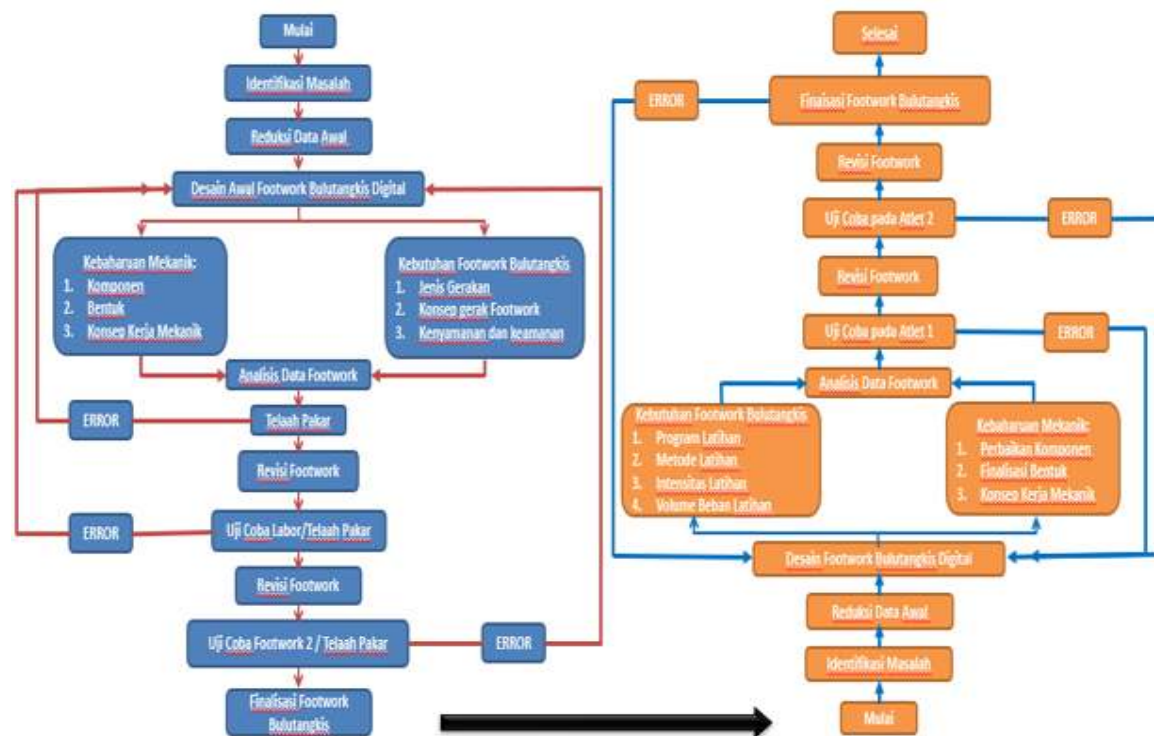


Figure 2. Flowchart of Research Implementation

In the needs analysis activity, focus group discussions and brainstorming activities were carried out regarding the current footwork test instrument and what components are needed so that the existing device can record more valid and reliable data and minimise human error while implementing and interpreting the data. This activity involves badminton experts who are coaches, administrators and athletes, as well as instrument experts consisting of experts in the field of sensors / IT and experts in sports measurement and evaluation tests. At the design stage, researchers and the work team continue to communicate actively in compiling and assembling components to match the results of the needs analysis.

The validation stage involves sensor / IT experts with the condition that the expert is an active researcher with an academic degree professor with a research concentration in IT and sensors. Badminton experts are nationally licensed coaches/badminton athletes. Sports measurement test experts are active researchers with academic degrees and professorships with research concentrations in measurement and evaluation tests. Validation using Expert Judgement techniques and validation using closed and open questionnaires. Validation data is analysed using quantitative descriptive statistical analysis.

After validation, the product undergoes revision following the suggestions given by the expert. It is tested for use in the UNP badminton club to ensure the product can be used as intended.

Results

The result of this research is a set of test instrument designs used to measure the footwork ability of badminton athletes. The details of the instrument design are as follows:

1. Background and Objectives

Footwork is one of the basic techniques that badminton athletes must own. Footwork or setting footsteps in badminton games is essential because footwork is a foot movement that brings the body to the correct position, making it easy to hit the shuttlecock. Good footwork owned by athletes can help them in the field because footwork functions to bring the body towards the arrival of the cock so that athletes get a good position in every anticipation of the shot and placement of the cock into the empty opponent's field. In the implementation of footwork, athletes are required to be able to move agile, agile and fast without losing balance and good coordination of movements to return the cock with good technique. For this reason, the right training program is needed so that there is an increase in the footwork ability of badminton athletes.

The basis for developing an exercise program is the initial data. Data is obtained from the measurement results. The better the measurement, the more valid the data obtained. A good instrument is

undoubtedly tested for validity and reliability. To prevent human error, it is highly recommended to use digital tools. Especially in badminton, the device used to measure badminton footwork so far is manual (stopwatch), so there are still doubts about the accuracy of the measurements. There is digital, but it does not match the field's distance and the tool's actual use (racket). The test only measures reaction and agility, so the characteristics of the definition of footwork that must be done are neglected. This is because the travel time given and the length and width of the field are not appropriate, resulting in athletes not carrying out the actual footwork movements. So, there may be errors in collecting the data needed. The purpose of the test instrument is to measure the ability of digital-based badminton footwork. This instrument is carried out with a unit of time in one-time execution of badminton footwork and how many corner points (sensors) can be achieved by each badminton athlete to obtain accurate data for achievement development.

2. Definition/term limit:

- 2.1 Test instructions for the badminton footwork ability.
- 2.2 A test is a measurement tool or instrument used to collect data.
- 2.3 Badminton footwork is the ability of athletes to follow in moving to a corner of the field and returning to a central position effectively measured in units of time.
- 2.4 The underhead punch technique, performed under the head, is also one of the basic punch techniques in badminton games.
- 2.5 Norms are a description of the level of achievement that is reflected through scores that can be compared
- 2.6 The test taker is the person who acts as the executor in collecting data
- 2.7 A test taker is a person who takes a test.

3. How to Implement the Badminton Footwork Test

- 3.1 Testee fills in their biodata in the "Badminton Practice" Android application.
- 3.2 Connecting the "Badminton Practice" app to a laptop via Bluetooth (HC-05).
- 3.3 Entering into Google Drive via email and connecting to Google spreadsheet (excel).
- 3.4 The testee stands on a sensor placed in the centre of the field (central).
- 3.5 The testee moves towards the corner of the field, and then the sensor will signal that the footwork has begun (start).
- 3.6 The testee moves to each corner point of the field consisting of 7 (seven) issues that are given a sensor at each corner point.
- 3.7 the testee performs the Underhead shot technique after arriving at each field corner.
- 3.8 After performing the stroke technique, the testee moves back to the centre position (central) with one foot over the centre sensor point of the field. This is counted 1 (one) time the direction of motion achieved.
- 3.9 Then, the testee moves back to the other corner of the field by hitting a shot and returning to the centre of the area.
- 3.10 The testee can decide which direction to move first without any direction from the test taker or the test screen.
- 3.11 The testee must complete the 7 (seven) field corner points that the sensor has given in the fastest time.
- 3.12 The data obtained is directly sent to the LCD layer (laptop) and stored on the Google Drive application (spreadsheet).
- 3.13 This test was performed as many as 3 (three) repetitions
- 3.14 Repetition is performed after rest + 15 seconds
- 3.15 Footwork ability is the number of shots achieved at each corner point of the court and back to the centre of the court within 7 minutes.



Figure 3. Product Illustration and Implementation Process

4. How the Tool Works

- 4.1 Preparing the test field.
- 4.2 Set up sensors to seven (7) corner points of the field, starting from the first sensor (1) under the net at the front of the field, second (2) under the net at the front of the right field, third (3) under the net at the front of the left field, fourth (4) at the centre of the right field, fifth (5) at the centre of the left field, sixth (6) at the back of the right field, seventh (7) at the back of the left field.
- 4.3 Press On/Off to activate the sensor marked by the yellow light and the sensor sensitivity marked by the green light.
- 4.4 The testee fills in the biodata in the "Badminton Practice" Android application.
- 4.5 Connecting the Android application "Badminton Practice" to the laptop via Bluetooth (HC-05).
- 4.6 Entering data into Google Drive via google spreadsheet (excel).
- 4.7 Each corner point of the field and the centre point of the area will be given a sensor that can read the achievement of the motion performed.
- 4.8 The racket, as a cock striking tool, will be given a sensor as a motion reader.
- 4.9 The testee stands at the centre point of the field's centre being sensorized.
- 4.10 The sensor will give a sound signal (beep) indicating the data and the sensor is ready for use.
- 4.11 The testee moves, and the sensor immediately gives a start signal (start). Time will run automatically until 7 (seven) corner points provided by the sensor have been completed.
- 4.12 The testee moves towards the corner point of the court, followed by an underhead shot made above the green light sensor.
- 4.13 The green sensor light is on if there has been no movement, and the light will turn off if there has been movement over the sensor.
- 4.14 The testee returns to the centre position (central) with one foot passing through the centre field sensor. This is counted 1 () time the direction of motion is achieved, and the data will enter the microcontroller.
- 4.15 Then, the testee moves back to the other corner of the field by hitting a shot and returning to the centre of the area.
- 4.16 The calculation of the time and times of footwork movement attempts followed by a shot and returning to the centre of the field will be automatically counted and recorded on the display monitor as achievement data.
- 4.17 Time will stop when all the corners of the field given by the sensor have been reached (finish).
- 4.18 Press the reset button for further data retrieval.

5. Product Assessment

Expert validation was carried out by involving three experts who assessed through evaluation instruments with closed and open questions, which were analysed using descriptive statistical analysis with the following assessment results:

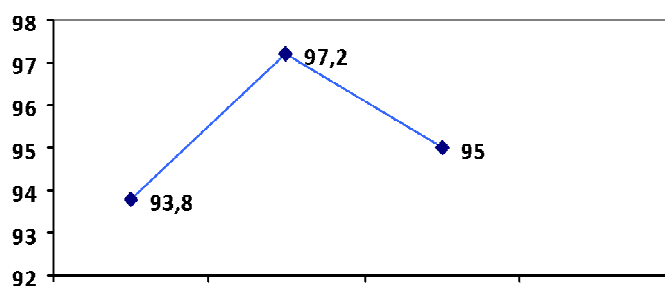


Figure 4. Expert assessment

Expert 1 is an expert in measurement and evaluation tests, which gave a product validation score of 93.8 by providing input on an open questionnaire related to the consistency of the sensors and rackets. Expert 2 is a badminton expert who also directly conducts field trials of the use of instruments, provides a score of 97.2, and revises the position of the sensor on the field. Expert 3 is an expert in IT/sensors, giving a score of 95 and adjusting the product on the sensor's sensitivity and the cross-section found on the racket so that the tool does not affect the racket's weight.

6. Product Revision

After validation, the tool was also tested on a small group to check the consistency of the tool's work and suitability for direct needs in the field. The instrument changed the design and was adjusted to the improvement suggestions submitted by experts during validation. The final form of the product can be seen in Figure 5.



Figure 5. Final Product Photo

Discussion

The product design was produced based on the brainstorming results and needs analysis conducted in preliminary research. This design results from development research in the third stage, which still needs to be validated by experts and product trials. Product revision and implementation will also affect the existence of this design in the field later. The results of this design are designed by adjusting to the actual needs and conditions in the area. Eight sensor points must be reached using a racket and a microcontroller directly connected to the sensor.

The data will be recorded and displayed now on the display and can be monitored and recapitulated either now or stored in the tool cloud. The sensor's sensitivity in reading the racket movement will significantly affect the data quality that can be displayed. The racket used in the test has also been modified to be easily read by the sensor. Because the size / cross-sectional area and movement speed will significantly affect the sensor in detecting movement.

The location of the eight sensor points is adjusted to the target area according to the results of the needs analysis. The results of the expert validation test concluded that the product is valid/feasible to be used as a badminton footwork test instrument. Reliability and practicality tests were carried out during small and large group trials involving practitioners, namely athletes and coaches. The final product development stage entered the constant testing phase of data input and output on sensors involving 30 members of the UNP badminton club and requires a further development phase.

The results of this research provide practical contributions for athlete trainers and badminton sports coaches in West Sumatra. In this research, the product is still a prototype and still requires an advanced development phase to test the reliability and effectiveness of the product. Theoretically, the product of this research contributes to the implementation of effective footwork in badminton matches. The use of sensor systems in badminton footwork measurement test instruments is a novelty in badminton coaching science in West Sumatra.

Conclusions

Digitalisation of test instruments and footwork data measurement is a significant requirement that must exist. The existence of human error in manual footwork tests results in the coach getting the wrong initial data in the interpretation of test result data. This creates difficulties for the coach in developing a program to achieve optimal performance. Brainstorming results and needs analysis involving coaches and athletes are the basis for preparing this footwork instrument.

The design of a sensor-based footwork test instrument using a racket as a medium read by the sensor is an effort to make the test instrument close to the actual situation. Based on the results of this study, a product design consisting of 8 sensor points with one microcontroller and an LCD screen with one modified racket was obtained. This product is designed by involving badminton experts, coaches, athletes and IT when making prototypes.

The product validation results concluded that the product is valid / very feasible to be used as a badminton footwork test instrument. The results of this research provide practical contributions for athlete trainers and badminton sports coaches in West Sumatra. In this research, the product is still a prototype and still requires an advanced development phase to test the reliability and effectiveness of the product. Theoretically, the product of this research contributes to the implementation of effective footwork in badminton matches.

The use of sensor systems in badminton footwork measurement test instruments is a novelty in badminton coaching science in West Sumatra.

Conflicts of interest - If the authors have any conflicts of interest to declare.

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