Motion-based technology uses sensors and the internet of things to support badminton motor skills examination

Una tecnología basada en el movimiento utiliza sensores y el Internet de las Cosas para ayudar a examinar las habilidades motoras del bádminton

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Abstract

Background: Motor skills, particularly agility and speed, are essential in badminton, yet a suitable test instrument remains lacking. Integrating Internet of Things (IoT) technology offers a precise and efficient solution for measurement. This study aims to develop an IoT-integrated badminton motor skills test instrument.
Objectives: (1) Develop IoT-based badminton skill test instruments and (2) Assess their feasibility.
Methods: This Research and Development (R&D) study follows a 4D model (Define, Design, Develop, Disseminate). The define stage includes needs analysis through field observation and literature review. The design stage involves developing an IoT-based agility and speed test instrument. The development stage focuses on prototyping and testing validity and reliability, while the dissemination stage involves implementation and evaluation.
Results: The define and design stages have been completed, confirming the need for IoT-integrated agility and speed test instruments for badminton. The designed agility test includes six sensor points across the court, while the speed test employs start and finish sensors. Both instruments feature monitors for control and result display.
Conclusion: This study successfully designed an IoT-based test instrument, with future work focusing on prototype development and feasibility testing. This innovation could revolutionize badminton motor skill assessment, improving athlete performance evaluation using modern technology.

Keywords

Eligibility, instruments, skills, agility, speed, badminton.

Resumen

Antecedentes: La agilidad y la velocidad son esenciales en el bádminton, pero aún falta un instrumento de prueba adecuado. La integración de la tecnología del Internet de las Cosas (IoT) ofrece una solución precisa para la medición. Este estudio tiene como objetivo desarrollar un instrumento de prueba de habilidades motoras de bádminton basado en IoT.
Objetivos: (1) Desarrollar instrumentos de prueba de habilidades de bádminton basados en IoT y (2) Evaluar su viabilidad.
Métodos: Este estudio de Investigación y Desarrollo (I+D) sigue el modelo 4D (Definir, Diseñar, Desarrollar, Difundir). La fase de definición analiza necesidades mediante observación y revisión bibliográfica. La etapa de diseño desarrolla pruebas de agilidad y velocidad basadas en IoT. La fase de desarrollo se centra en prototipos y pruebas de validez y fiabilidad, mientras que la difusión abarca la implementación y evaluación.
Resultados: Se completaron las fases de definición y diseño, confirmando la necesidad de pruebas integradas en IoT para bádminton. La prueba de agilidad incluye seis sensores en la pista, y la de velocidad emplea sensores de salida y llegada, con monitores para control y visualización.
Conclusiones: Este estudio diseñó con éxito un instrumento basado en IoT. El trabajo futuro se enfocará en el desarrollo de prototipos y pruebas de viabilidad para optimizar la evaluación del rendimiento en bádminton.

Palabras clave

Elegibilidad, instrumentos, habilidades, agilidad, velocidad, bádminton.

Introduction

Motor skills are an essential part needed as specific and complex basic skills for playing, exercising, dancing, gymnastics, outdoor education, and recreational activities (Kiram, 2016; Sgrò et al., 2013; Bakhtiar et al., 2015; Haywood et al., 2012). In badminton, motor skills are essential to pay attention to, especially in the player's agility and speed. It should be noted that badminton is a very dynamic racket sport in its game, incorporating several elements such as speed, precision, high-intensity action, anticipation and interval breaks, in which the two competing players must act and react during the rally, i.e. the interaction of technique, tactics and decision-making to gain a temporal advantage and position over their opponent to win points (Barreira et al., 2016; Phomsoupha & Laffaye, 2015; Chow et al., 2014; Abián et al., 2014).

Currently, badminton rules have changed players' performance with longer matches that incorporate a more aggressive style of play, different tactical patterns, and shorter time between strokes during longer rallies (Seth, 2016; Laffaye et al., 2015). Abián et al. (2014) stated that badminton is evolving with an increase in the intensity of rallies, sets, and matches. The authors argue that the scoring system has changed the performance profile of players with constant adaptation to high-intensity games and demands more rallies played, more strokes per rally, and more variation in rally times and breaks during rallies.

As a result of this ever-growing performance trend, most of the research on badminton (Hughes et al., 2008; Gawin et al., 2015; Cabello et al., 2004) focused on the identification of temporal characteristics and the notation of male and female players during elite competitions. Abian-Vicen et al. (2013) analyzed 20 single matches (only those played in two sets) from the Beijing Olympics (2008) (n = 10 matches for each gender), with total match duration, rally time, rest time, number or rally, strokes per rally, and greater stroke frequency for male players compared to female players.

In contrast, female players have a higher work density and play longer match times than male players. The authors found no difference in temporal variables between sets 1 and 2. In addition, shorter rally times range between 3 and 6 seconds and are more common in female players, while longer rally times (>16 seconds) are more common in male players (Abian-Vicen et al., 2013).

Furthermore, Gawain et al. (2015) investigated the performance characteristics of each sport of badminton (singles and doubles for each gender, and mixed doubles) over 50 matches played by the world's top 10 players. These authors confirm the findings from Abián et al. (2014), where male players performed with a higher intensity, while female players performed with a more significant workload and longer playing time, compared to the opposite sex.

Some time ago, Valldecabres et al. (2017) studied the differences between men's and women's singles matches during the 2015 Badminton World Championships. Their principal findings showed that male players experienced a more significant total match duration, actual playing time, effective playing time (%), rally time, strokes per rally, rest time, break time at point intervals (break time at point 11), and strokes per game than women's players. However, women showed greater work density, stroke frequency, and rest time between sets than male players.

Based on some of the studies on badminton motor skills, especially agility and speed, an evaluation with adequate instruments is needed. At this time, no instrument can accommodate this need. So, it is necessary to develop an instrument that measures and checks the agility and speed of badminton.

In addition, this problem can be overcome by creating an Internet of Things (IoT)-Based Fundamental Motor Skills test instrument. Various applications and needs have been developed using IoT, such as E-Commerce Website Design, Sports Equipment Sales, and Website-Based Sports Facilities Mapping Application (PSO) Design (Hidayat & Setiawan, 2017). By utilizing the advantages of this IoT, all motor ability test results can be appropriately recorded on the website and processed as information on the development of a person's badminton motor skills.

Motor learning innovation refers to the demands of being integrated with information technology according to the needs of the digital era (Pretto & Curró, 2017; Asuman et al., 2018; Alja'am et al., 2017; Salleh & Laxman, 2015; Ozdamli 2017). Motor learning at this time requires development in the form of applications or sensor technology that can facilitate the learning process, making it innovative, engaging,

and practical. Integrated sensor systems are relevant in supporting learning (Specht, 2014). Developing motor skills is a potential mechanism to reduce the negative impact of physical activity, health, and obesity rates (Lima et al., 2019; de Bruijn et al., 2019).

The Internet of Things (IoT) is widely used in today's technological developments. IoT can be interpreted as Internet communication between one device and another. This advancement in IoT technology can facilitate various kinds of work (Setiawan et al., 2019). The Internet of Things (IoT) is used on devices and products requiring connectivity, such as wireless sensors, smart meters, and home automation systems. The quality of an IoT product can be seen from several parameters, namely low power consumption, more extended range, wireless connectivity and higher data processing capabilities (Selay et al., 2022).

The Internet in the world of sports can be used by utilizing the data contained in a website. A website is a visual part of the Internet, a web application because it can perform specific actions and help you perform certain activities. Websites are applications that contain multimedia documents (text, images, sounds, animations, videos) and the HTTP protocol (EMS Team, 2014).

Based on the description above, developing motor skills test instruments for agility and speed components integrated with the Internet of Things (IoT) for badminton is an urgent need. This instrument is expected to provide a more accurate and efficient evaluation of the motor skills of badminton athletes, as well as in line with the development of technology and the demands of the digital era in the sports field. In addition, the development of this instrument is also expected to contribute to efforts to improve Indonesia's badminton achievements and support government programs for health independence.

Therefore, this study aims to develop and test the feasibility of an IoT-integrated badminton skill test instrument, focusing on agility and speed components. The results of this study are expected to significantly contribute to developing a more modern and effective motor skill evaluation method in badminton.

Method

This study adopts a Research and Development (R&D) approach with a 4D development model (Define, Design, Develop, Disseminate) adapted from Thiagarajan et al. The focus of the discussion in this article is limited to the first two stages, namely, Define and Design. The Define stage is the first step in the instrument development process, where an initial analysis is carried out to identify the problems faced in implementing the badminton motor skills test. This analysis includes two main methods: direct observation and literature study.

In direct observation, the research team made thorough observations in the field to see the process of implementing the current motor skills test. The observation results show that the test process still relies on the tester manually, which has the potential to cause inaccuracies and inefficiencies. Meanwhile, literature studies are conducted by examining various sources related to motor skills in badminton, especially agility and speed components, as well as the latest research on the use of technology in measuring sports skills. The results of the analysis at the define stage show the need for a tool that can measure the agility and speed of badminton athletes in a specific, accurate, and integrated manner with IoT technology.

Based on the results of the analysis, the research team then proceeded to the design stage, where badminton agility and speed test instruments were designed. This design process involves several stages, from conceptualization to sketching to detailed design. In the conceptualization stage, the research team formulated the basic concept of the tool to be developed, taking into account the specific needs in measuring the agility and speed of badminton. Next, an initial sketch is made for the visualization of the tool to be developed, including the main components of the tool and its layout. Based on the initial sketch, a detailed design was carried out for each tool component, including each component's technical specifications, dimensions, and functions.

The design stage involves the design of two main tools: an agility test tool and a speed test tool. The agility test kit consists of a monitor stand that controls the test's course and displays the final result, as

well as six standing parts (A) that ensure that the test has performed movements according to the specified pattern. Meanwhile, the speed test tool consists of a monitor stand, a start stand that marks the starting position of the test, and a finish stand that marks the final position of the test. Both tools are designed to measure travel time in seconds, integrating IoT technology to ensure measurement accuracy and ease of data processing.

The design produced at this design stage is the basis for the next stage of development, where a prototype of the tool will be created and tested. The resulting design is expected to answer the need for test instruments that are more accurate, efficient, and in accordance with technological developments in the field of sports. This research has the potential to revolutionize the way we evaluate motor skills in badminton, making a significant contribution to the development of a more modern and effective evaluation method.

Results

The result of this study was to create two designs to measure agility and speed in the game of badminton. The define stage is the first step in this study, which aims to analyze and identify the problems that need to be solved related to the development of motor skills test instruments for badminton. At this stage, researchers carry out several activities to obtain various information related to the product to be developed.

Initially, the researcher undertook a comprehensive analysis to pinpoint the challenges encountered in implementing motor skill tests for badminton athletes. Through direct field observations and extensive literature reviews, it was revealed that there is a lack of a standard and universally accepted motor skill test instrument for measuring agility and speed in the context of badminton. Currently, the process of conducting motor skills tests for badminton athletes is reliant on manual and subjective methods.

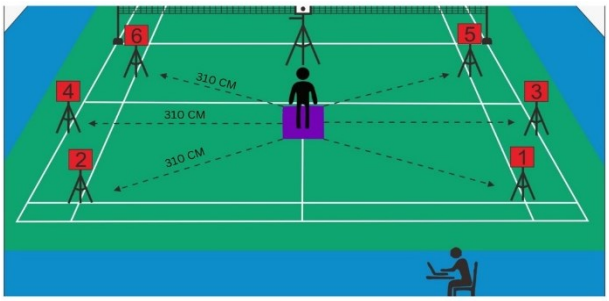
Furthermore, the researcher conducted a more profound analysis of speed and agility factors essential to badminton. Speed in badminton refers to a player's ability to move quickly on the court, which includes the speed of foot movement, hand speed, and acceleration ability. Meanwhile, agility is the ability to change direction quickly and efficiently, influenced by factors such as rapid change of direction, body coordination, and stability and balance. These two components are essential for a badminton athlete to play well.

As a result of the analysis, the researcher has determined that a specialized test instrument for measuring speed and agility in badminton is essential. This instrument should be capable of accurately and objectively recording test results, and should be easily accessible through the use of information technology. Such a tool is expected to significantly enhance the monitoring and evaluation of badminton athletes' motor skill development by coaches and clubs.

In the development process, validity and reliability tests have been carried out with validity results based on Sig. (2-tailed) <0.05, so that all items representing the tested instruments can be said to be valid. Then in the reliability test of the material and media got an ICC value of 0.730 and 0.784 which means it has a good level of reliability.

Thus, the defined stage in this study has succeeded in identifying the need to develop badminton motor skills test instruments integrated with Internet of Things (IoT) technology. The vital information obtained at this stage will be the basis for the next stage in the product development process.

Figure 1. Design of Badminton Agility Test Equipment



The badminton agility test instrument consists of the following tools:

The monitor stand, as a tool that functions to control the course of the test, from the start of the test to the end of the test and shows the final results of the test.

- Standing part 1, as a tool that functions to ensure that the testi has performed movement 1.
- Standing part 2, as a tool that functions to ensure that the testi has performed movement 2.
- Standing part 3, as a tool that functions to ensure that the testi has performed the 3 movement.
- Standing part 4, as a tool that functions to ensure that the testi has performed the 4 movement.
- Standing part 5, as a tool that functions to ensure that the testi has performed the 5 movement.
- Standing part 6, as a tool that functions to ensure that the testi has performed the 6 movement.

The movement guidelines that can be done by the testi are as follows:

- Movement 1, running to the right back area of the badminton court he occupies.
- Movement 2, running to the left back area of the badminton court he occupies.
- Movement 3, running to the right side area of the badminton court he occupies.
- Movement 4, ran to the left side area of the badminton court he occupied.
- Movement 5, running to the right front area of the badminton court he occupies.
- Movement 6, running to the front left area of the badminton court he occupies.

During the implementation of the agility test, an assessment will be carried out by calculating the travel time from the beginning, namely movement A to the end, namely movement F in second conversion.

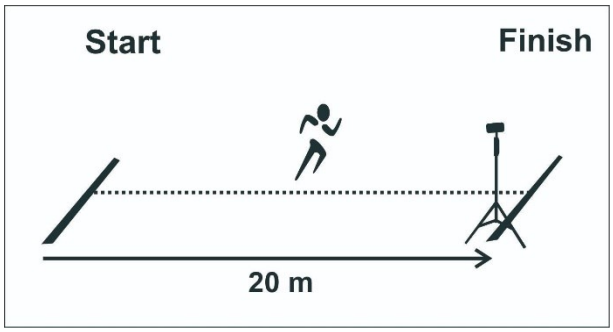
The badminton speed test instrument consists of the following tools:

The monitor stand, as a tool that functions to control the course of the test, from the start of the test to the end of the test and shows the final results of the test.

Stand start, as a marking tool where the initial position of the test is located when going to carry out the speed test.

Stand finish, as a marker tool where the end of the test is located after carrying out the speed test.

Figure 2. Design of Badminton Speed Test Equipment



During the implementation of the speed test, an assessment will be carried out by calculating the travel time from the beginning, namely the starting to the end of the stand position, namely the finish position in second conversion.

Discussion

Developing a motor skills test instrument for speed and agility components integrated with the Internet of Things (IoT) for badminton athletes is an innovative step in an effort to improve the quality of coaching and evaluation of athletes. This research uses the Research and Development (R&D) method with a 4D model (Define, Design, Develop, Disseminate). The Define stage involves identifying the problem and the needs of the users, while the Design stage focuses on creating a solution to the identified problem. The development stage, the next phase of this research, will involve building and testing the solution. The final stage, Disseminate, will involve sharing the results and the developed solution with the relevant stakeholders.

At the Define stage, the initial analysis showed the need for a tool to measure agility and speed, specifically for badminton. This is in line with the findings of Abian-Vicen et al. (2013), who highlighted the difference in performance characteristics between male and female players in badminton and the importance of speed and agility in the game. In addition, developing badminton regulations that lead to more intensive and aggressive play (Laffaye et al., 2015) further emphasizes the importance of accurate measurements for these two components.

Analyzing speed and agility factors in badminton reveals the complexity of both components. Speed involves not only the movement of the legs but also the speed of the hands and the ability to accelerate. Meanwhile, agility includes quick changes in direction, body coordination, stability, and balance. This complexity requires a more sophisticated measurement instrument than conventional methods.

In the Design stage, this research resulted in an innovative design of agility and speed test equipment. The agility test consists of six standing parts (A-F) representing various areas of the badminton court, as well as a monitor stand to control the course of the test. The monitor stand is used to set the parameters of the test, such as the starting point and the direction of movement. This design allows for more comprehensive measurements of agility, including movements in different directions relevant to the game of badminton. Meanwhile, the speed test tool uses a start and finish stand, which allows for high-precision measurement of travel time.

The integration of IoT technology in this test instrument is a significant breakthrough. Setiawan et al. (2019) state that IoT can increase accuracy and efficiency in data collection and analysis. In badminton motor skills tests, test results can be recorded in real-time and accessed through the website, allowing for more in-depth analysis and more effective monitoring of athletes' development.

This technology-based approach also aligns with the global trend of using technology to improve sports performance. Phomsoupha and Laffaye (2015) revealed that technology-based performance analysis is increasingly vital in developing elite athletes. The test instruments developed in this study have the potential to provide more accurate and comprehensive data, which in turn can support more informed decision-making in athlete training and development programs.

However, keep in mind that this research is still in the development stage. The next stage, Develop, will involve prototyping and testing the validity and reliability of the instrument. It is essential to ensure that the instrument developed can measure what it is supposed to measure and provide consistent results.

Although the development of this IoT-based motor skill test instrument offers great potential in measuring the speed and agility of badminton athletes, there are several limitations that need to be considered. First, the testing of this instrument is still limited to the design stage and has not been fully applied to a wider population. This may limit the generalizability of the results. Second, IoT-based measurements depend on the stability of network connectivity and hardware robustness, which can be affected by environmental conditions, such as signal interference or device damage. Third, the cost of procuring and maintaining these IoT-based instruments may be an obstacle for sports clubs or institutions with limited budgets. Future research is therefore recommended to conduct more extensive field testing, identify solutions to overcome technical obstacles, and explore more affordable cost options for wider adoption of these instruments among coaches and sports institutions.

Overall, the development of this IoT-based motor skills test instrument has great potential to improve the quality of badminton coaching in Indonesia. With more accurate and comprehensive data, coaches

and athletes can make more informed decisions in the training process. This, in turn, is expected to lead to significant improvements in Indonesia's badminton achievements in the international arena, potentially helping Indonesian athletes to compete more effectively on the global stage.

Conclusions

Based on the research progress report presented, developing a motor skill test instrument for agility and speed components integrated with the Internet of Things (IoT) for badminton is an innovative step to improve the quality of measurement and evaluation of athlete performance. This research is motivated by the importance of motor skills, especially agility and speed, in a dynamic and competitive badminton sport. Although various studies have analyzed the temporal characteristics and notation of elite badminton players, there are not yet adequate instruments to measure agility and speed, specifically in the context of this sport.

The research method used is research and development (R&D) with a 4D model (Define, Design, Develop, Disseminate). This model involves four key stages. The Define stage is where an initial analysis is carried out to identify the need for a measuring tool that can accurately and objectively evaluate the agility and speed of badminton athletes. The Design stage is where the innovative agility and speed test instruments are designed. The development stage is where these instruments are created and tested. The research findings are shared with the broader community in the dissemination stage.

The design stage has resulted in the design of innovative agility and speed test instruments. The agility test instrument consists of six standing parts (A-F) representing different areas of the badminton court, as well as a monitor stand to control the course of the test. Meanwhile, the speed test instrument is designed with a standing start, finish, and monitor stand. Both instruments are designed to measure an athlete's time to complete a series of movements or a certain distance, with results converted in seconds.

The integration of IoT technology in these test instruments is a significant advantage. The use of IoT allows for automatic and accurate recording of test results, as well as facilitating efficient storage and analysis of data through websites. This improves the objectivity and accuracy of measurements and facilitates continuous monitoring of the development of athletes' motor skills.

The development of this instrument is in line with the demands of the digital era and national research priorities, especially in the field of health independence and the development of sports instruments. In addition, this research also has the potential to make a significant contribution to the development of badminton achievements in Indonesia, which is one of the country's leading sports. By providing a more accurate and objective way to measure agility and speed, this research could help identify and develop future badminton stars, thereby enhancing Indonesia's standing in the sport.

Although the study is still in the development stage, the provisional results show promising potential. However, it should be noted that the next stage, namely prototyping and validity and reliability testing, will be crucial in determining the effectiveness and feasibility of this instrument. There may be challenges in ensuring the accuracy and reliability of the measurements, as well as in integrating the IoT technology with the test instruments. Field testing involving badminton athletes will provide further insight into the applicability and practical benefits of this instrument.

In conclusion, the development of this IoT-based motor skills test instrument represents a step forward in measuring the performance of badminton athletes. If successfully implemented, this instrument can change how coaches and sports scientists evaluate and develop the motor skills of badminton athletes. The research also paves the way for further integration between technology and sport, which could improve athlete performance and our understanding of critical aspects of high-level sports performance.

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