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# Development of Automated "Hexagonal Obstacle Test" in Sports Agility Measurement

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***Abstrak***

*Pengukuran kelincahan dalam olahraga dengan "hexagonal obstacle test" yang menggunakan stopwatch dengan bantuan manusia sebagai tester diyakini hasilnya kurang objektif. Penelitian ini secara umum bertujuan untuk mengembangkan instrument pengukuran kelincahan "Hexagonal Obstacle Test" yang mampu mengukur kelincahan seseorang secara elektronik dan lebih objektif. Secara khusus penelitian ini bertujuan untuk: (1) menggantikan pengukuran kelincahan yang secara konvensional, karena alat ukur ini akan bekerja secara elektronik; (2) mengembangkan hexagonal obstacle test yang bekerja secara elektronik memanfaatkan teknologi Infrared (IR)/ Laser Diode dan Real-¬Time Clock (RTC) sehingga diproses oleh microcontroller agar pelaksanaan tes dilakukan secara automasi; (3) mengembangkan sebuah hexagonal obstacle test yang lebih modern, praktis, efektif, objektif dan efisien. Penelitian ini menggunakan pendekatan penelitian dan pengembangan produk yang terdiri dari beberapa langkah, yaitu observasi, perencanaan dan perancangan, percobaan dan pengujian, dan analisis. Hasil analisis data menunjukkan nilai validitas produk sebesar 0,975146897 dan nilai reliabilitas produk sebesar 0,995983936. Kami berkesipulan bahwa produk hexagonal obstacle test automasi ini valid dan reliabel untuk mengukur kelincahan.*

***Kata kunci****—Automasi, Hexagonal Obstacle Test, Kelincahan Olahraga, Laser diodes*

***Abstract***

*The measurement of agility in sports using the "hexagonal obstacle test" which used a stopwatch with human assistance as a tester is believed to be less objective. In general, this research aims to develop an agility measurement instrument "Hexagonal Obstacle Test" which is able to measure a person's agility electronically and more objectively. Specifically, this research aims to: (1) replace conventional agility measurement, because this measuring instrument will work electronically; (2) developing a hexagonal obstacle test that works electronically by utilizing Infrared (IR)/ Laser Diode and Real-Time Clock (RTC) technology so that it is processed by a microcontroller so that the test is carried out automatically; (3) developing a hexagonal obstacle test that is more modern, practical, effective, objective and efficient. This study uses a research and product development approach which consists of several steps, namely observation, planning and design, experimentation and testing, and analysis. The results of data analysis showed that the product validity value was 0.975146897 and the product reliability value was 0.995983936. We conclude that the hexagonal obstacle test automation product is valid and reliable for measuring agility.*

***Keywords—****Automation, Hexagonal obstacle test, Sport agility, Laser diodes*

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## 1. INTRODUCTION

The physical ability to quickly complete a planned change of direction is a vital component of many field sports [1][2]. This physical component is known as agility. Several types of tests can be used to measure the agility of an athlete. Among them is the hexagonal obstacle test, zig-zag test, 505 agility test, Illinois agility run test, lateral change of direction test, quick feet test, burpee test, dribbling agility test, Zig-zag dribbling test, and T drill test [3][4]. The methods and tools used in these tests are still used today and they are classified as conventional. The tools needed are a circuit and a stopwatch. In its operation the stopwatch uses human assistance. There are human errors that are considered detrimental to athletes in carrying out this test. Human error occurs at the start of the test signal and at the end of the test, where the tester presses the start or stop button of the stopwatch. There is a gap between the performing testee and the tester pressing the start or stop button of the stopwatch. Until now, this test tool has no practical development and works with an electronic system that carries an automation system to measure this agility effectively and efficiently. Infrared distance measuring technology has been widely used in several scientific fields, but there is still little use of this technology, especially in the field of sports tests and measurements.

Several overseas sports measuring instrument manufacturers have been selling sports measuring instruments. however, the price set is still relatively expensive.Currently, on a national scale, infrared sensors have been used in the development of measuring instruments [5], and also on the leg power gauge [6]. Data from statistical calculations show that the leg power measuring instrument that utilizes infrared technology has a high validity value and a very high-reliability value [6]. From the research results, it was found that the jump height measuring instrument developed with the use of infrared technology has a high enough validity value so that it can be said that the tool developed is following a similar measuring instrument [5]. This shows that infrared technology can be utilized and developed in the field of sports tests and measurements.

Innovation is needed because no technology can measure agility electronically and use this practical tool. The purpose of this research is to produce a product. The expected product is a practical agility measuring device technology that uses an electronic system. The products we produced also reduce the human error described earlier. The timing of the testee who performs the test starts right when the testee leaves the start position. Time stops just as the test completes three circuits. In its operation, the tester does not need to press the start or stop timer button. We hypothesize that the development of this agility measuring instrument can not only validly and reliably measure a person's agility, but also be more practical than conventional ways of measuring agility.

## 2. METHODS

### *2.1. Materials*

#### *2.1.1. Laser Diodes*

Previous research states that infrared sensors can be used as proximity sensors [5]. Haryono & Pribadi's research uses four infrared sensors to measure the height of the jump using the cm scale [6]. In other research, pyroelectric infrared is used as a motion sensor [7]. Based on the validity and reliability test, the jump power meter using infrared has a high validity value and a very high-reliability value. [6]. The infrared sensor is easy to detect distance because it adopts the triangulation method [5]. Infrared used in this research is a laser diode which consists of two components, namely the transmitter and receiver. The laser functions as a sensor to stop the running time automatically after the hexagonal obstacle test are completed by the subject.

*2.1.2. Microcontroler*

The microcontroller used in this study is "Arduino Nano." Without doing any configuration, once an Arduino board is removed from its packaging box it can be directly connected to a computer via a USB cable, besides that, it also flows 5 Volt DC current so that the arduino board does not require an external power source [8][9]. This Arduino controller provides a simpler implementation of the system compared to other types of controllers in the literature [10]. This microcontroller is a high-performance device that has low power A VR S-bit Microcontroller with 32K bytes in-system and advanced reduced instruction set computing [11]. Arduino has 14 digital input/output ports that provide PWM signals to 6 servo motors and 6 analog input ports, it also contains a 16 MHz crystal oscillator and a USB cable for push through programs [9].

*2.1.3. Light Emitting Diode (LED) Seven Segment Display (SSD)*

SSD is a display device consisting of 7 LEDs that form the number 8 and 1 LED for each point. The SSD display only contains numbers from 0 to 9 or the character set “0123456789” [12]. This product uses a seven-segment measuring 2 inches. The seven-segment board used consists of 6 digits. Where the display displayed is the minute, second, and millisecond. A seven-segment display is simply a figure of eight groupings of segments that are identified as A, B, C, D, E, F, and G [13]. Several types of Seven Segments Display, including Incandescent bulb, Fluorescent lamp (FL), Liquid Crystal Display (LCD) and Light Emitting Diode (LED) [14]. The seven segments that have been used in this study are the LED type.

*2.2. Methods*

The Research and Development (R&D) method is used in this study to produce a hexagonal obstacle test automation product and test the product's effectiveness. Peterson mention that artifacts from R&D can include the development of new tools, products, or processes [15]. Research and development design is a study conducted in the framework of product development [16]. The research steps from the R&D method are problem identification, literature study, designing and developing products, product performance testing, evaluating product testing results, and explaining the results of product testing [17].

*2.2.1. Research and Development Procedures*

The following are the stages of implementing the research carried out, several methods were being carried out to achieve the objectives of this research.
*Observation Method*, includes observations to be made by researchers in the field. Observation of the current development of sports and health technology. Observations were also made on the needs of sports and health technology, especially in Indonesia.

*Planning and Design Methods*, this method is planning and designing a product work system so that it can be used as a product that can be used in sports and health tests and measurements. Planning and product design in this research is an agility measurement tool in the form of a hexagonal obstacle test instrument based on laser and microcontroller.

*Experiment and Testing* Methods, this method is used to try and test products to produce a valid and reliable system. The system performance is also tested so that the results can be justified. External validity is done by correlating the product with conventional measuring instruments. Reliability is done by using the Spearman-Brown method of halving by correlating the data obtained from the automation product.

*Analysis*, the analysis is carried out by observing the test results with the actual situation and finding solutions to fix problems that may occur in the product. If a solution is found for product improvement, the research will be repeated from the planning and design methods to the re-analysis stage.

### 2.2.2. Participants

Testing the validity and reliability of the product required test participants. Agility measurement uses hexagonal obstacle test automation and conventional measurement using a stopwatch. The product trial participants were 74 students of PJKR program study in Muhammadiyah University of Bangka Belitung. Participants were levels 5 and 7 in the odd semester of the 2020/2021 academic year. The mean ± SD age of the participants was (21.12 ± 1.07) years. Participants ranged in age from 19 to 24 years. Participants consisted of 61 men and 13 women.

### 2.2.3. Research Instrument

Classically agility is defined as the ability to change direction quickly and accurately, meanwhile, in more recent publications, some authors define agility as a change in the direction of the whole body as well as the fast movement and change in the direction of the limb [18]. Agility is a change in direction or speed of the whole body rapidly in response to an activity that requires a stimulus [19]. Agility is one of the most commonly measured variables during athletic performance testing [20]. According to the research results of Jasmin, Montgomery, & Hoshizaki, the hexagonal resistance test is good agility measuring instrument [21]. The purpose of the Hexagonal Obstacle Test is to monitor the agility of athletes. This test circuit consists of six hexagonal side markers, each side having a length of 66 cm [3][21]. The Hexagonal Obstacle Test is a simple and easy to learn test that can be carried out in a confined space, making it ideal for evaluating agility in a laboratory environment [20]. The circuit shape can be seen in figure 1.

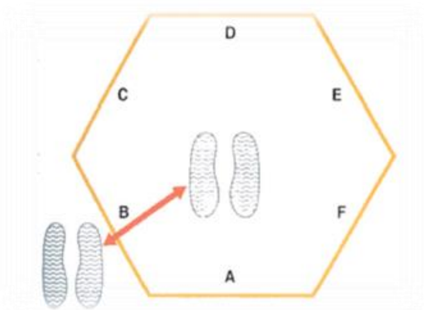


Figure 1 Hexagonal Obstacle Test Circuit
Image Source: Brian Mackenzie (2008: 57).

The procedure for implementing the hexagonal obstacle test is as follows: (1) The athlete stands in the center of the hexagon, facing line A; (2) throughout the test time, the athlete must face the A-line; (3) at the GO / Start command, the stopwatch starts and the athlete jumps with both feet over line B and back to the center, then over line C and back to center, then line D, and so on; (4) when the athlete jumps over line A and returns to the center, it is considered a circuit; (5) the athlete will complete three circuits; (6) after completing three circuits, the stopwatch is stopped and the time is recorded; (7) each athlete gets 2 chances to do the test; (8) after completing the second test, the average time of these 2 occasions was taken; (9) if the athlete jumps the wrong line or lands on the line then the test is repeated [3]. The test procedure is a conventional procedure. The implementation of these conventional procedures often results in less objective measurement or recording of time. This often occurs due to human error factors. To minimize this, innovation is needed that takes advantage of advances in science and technology that exist today. After obtaining the average results from 2 times the test implementation, then the assessment is carried out by comparing the following normative table.

Table 1 Normative of Hexagonal Obstacle Test

| Gender | Excellent | Above Average | Average | Below Average | Poor |
|---|---|---|---|---|---|
| Male | <11.2 secs | 11.2-13.3 secs | 13.4-15.5 secs | 15.6-17.8 secs | >17.8 secs |
| Female | <12.2 secs | 12.2-15.3 secs | 15.4-18.5 secs | 18.6-21.8 secs | >21.8 secs |

Table Source: Mackenzie (2008: 58).

Arnot & Gaines, in his book sports talent, explains the procedural and tools needed in carrying out the hexagonal obstacle test agility test. The test is still carried out using a stopwatch operated by a supervisor [22]. In this procedure, human error often occurs. It is unfortunate that with current technological advances, the implementation of agility tests has not used an automated system that is able to minimize the occurrence of human errors. In fact, the most recent research on agility conducted by Bekris et. al. in 2018 it has not used an automation system. The research they conducted in measuring three different types of agility tests, namely, the Illinois agility test, the zig-zag dribbling test, and the dribbling agility test [4]. They still do the three agility tests conventionally because there is no technology with an automation system for these tests.

The instruments used in this study included: 1) SEIKO S23601P stopwatch (Cal.S056), and 2) Hexagonal obstacle test (Automation) products. The test was conducted in the sports laboratory at the Muhammadiyah University of Bangka Belitung. Measurement and data collection is carried out by a competent tester.

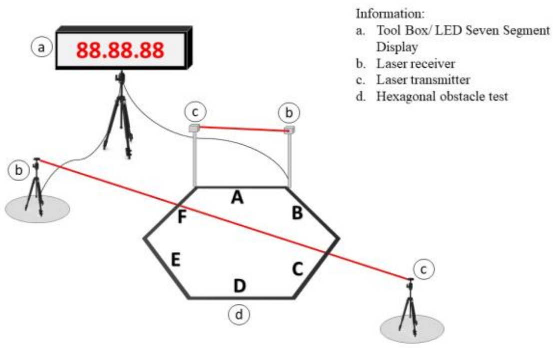


Figure 2 Hexagonal Obstacle Test Automation Product Design

The concept of hexagonal obstacle test using a seven-segment and laser is a development of the conventional hexagonal obstacle test as can be seen in Figure 2. Utilizes infrared sensor technology in the form of a laser diode, and an Arduino Nano microcontroller to obtain data in the form of the duration of time the subject completes the test. Then obtained data display in the form of travel time from the subject as measured on the seven segments LED. Figure 2 is also the initial design of the automation-based Hexagonal Obstacle Test product.

*2.2.4. Data Colecting*

The data of this research were obtained from the results of agility measurements using conventional and automated hexagonal Obstacle Test. The type of data obtained is quantitative data in the form of time units in seconds. Data collection was carried out on October 1, 2020, at the Sports Laboratory of Universitas Muhammadiyah Bangka Belitung.

*2.2.5. Statistical Analysis*

The product validity is done by correlating the agility measurement result data with a stopwatch and automation using the hexagonal obstacle test automation product. This validity is also called external validity. The external validity of the instrument was tested by comparing it to look for similarities [23]. Product reliability was tested by the internal consistency method. The test results data between odd and even groups using the hexagonal obstacle test automation product were analyzed by the product-moment correlation. Furthermore, tested with the technique of halves from Spearman-Brown (Split Half). Internal consistency reliability refers to the extent to which instruments within a measure actually measure the same phenomenon [24]. To find out the validity and reliability values of the hexagonal obstacle test automation is calculated using the product-moment formula, as in (1). Furthermore, for reliability, it is followed by the Spearman-Brown formula, as in (2). Statistical significant level was set at 0.05.

$$r_{xy} = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{\{N\sum x^2 - (\sum x)^2\}}\sqrt{\{N\sum y^2 - (\sum y)^2\}}} \quad (1)$$

$$r_i = \frac{2r_b}{1 + r_b} \quad (2)$$

## 3. RESULTS AND DISCUSSION

The product is made according to the initial planning and design of the hexagonal obstacle test automation product. The product consists of several components, including start laser transmitter (a), start laser receiver (b), end laser transmitter (c), end laser receiver (d), and toolbox which is also an LED Seven Segment Display (e).

Figure 3 Realization of Hexagonal Obstacle Test Automation Products

Data analysis from the product trial results found a difference between the mean ± SD of conventional data (17.60 ± 2.30) seconds, and the mean ± SD of automation data (16.88 ± 2.17) seconds. The difference in travel time between conventional and automation products that we found is 0.72 seconds.


Figure 4 Hexagonal Obstacle Test Automation Product Testing

We found that average travel time measured conventionally using a stopwatch was 0.72 seconds longer. This is because the measured subject did not start correctly at the same time the tester pressed the stopwatch start button during the start cue. This analysis supports our hypothesis that the travel time for measuring the agility of the conventional hexagonal obstacle test using a stopwatch is not objective.

The external validity of the product obtained a value of 0.975146897. Each correlation contains three meanings, namely whether there is a correlation, the direction of the correlation, and the magnitude of the correlation [25]. The product validity value of the hexagonal obstacle test shows that there is a correlation, the direction is positive, and the correlation index is large because it is close to number one.

The following is an explanation regarding the data description and the results of data analysis obtained from the hexagonal obstacle test automation and conventional product trials using a stopwatch.

Table 2. The Data of Agility Measurement Result

| Participants | Age (Years) | Results of Hexagonal Obstacle Test | | Participants | Age (Years) | Results of Hexagonal Obstacle Test | |
|---|---|---|---|---|---|---|---|
| | | Conventional | Automation | | | Conventional | Automation |
| 1 | 19 | 17.42 | 16.39 | 38 | 20 | 13.11 | 12.93 |
| 2 | 22 | 15.36 | 14.76 | 39 | 20 | 18.41 | 17.62 |
| 3 | 21 | 16.93 | 16.47 | 40 | 21 | 17.44 | 16.73 |
| 4 | 21 | 16.87 | 16.64 | 41 | 20 | 17.40 | 16.79 |
| 5 | 20 | 16.17 | 15.44 | 42 | 20 | 18.15 | 17.17 |
| 6 | 20 | 20.78 | 20.23 | 43 | 21 | 17.12 | 16.79 |
| 7 | 20 | 13.72 | 13.49 | 44 | 20 | 17.45 | 16.53 |
| 8 | 21 | 16.78 | 15.12 | 45 | 21 | 18.80 | 18.01 |
| 9 | 20 | 15.35 | 15.95 | 46 | 21 | 21.10 | 20.21 |
| 10 | 20 | 17.58 | 16.82 | 47 | 21 | 16.88 | 15.94 |
| 11 | 21 | 24.04 | 23.46 | 48 | 22 | 17.82 | 16.27 |
| 12 | 21 | 15.96 | 15.16 | 49 | 21 | 17.01 | 16.26 |
| 13 | 21 | 23.86 | 22.83 | 50 | 23 | 18.15 | 16.84 |
| 14 | 24 | 21.75 | 21.04 | 51 | 22 | 18.81 | 17.37 |
| 15 | 20 | 19.35 | 18.34 | 52 | 22 | 21.66 | 20.46 |
| 16 | 20 | 17.75 | 16.99 | 53 | 23 | 17.09 | 16.18 |
| 17 | 20 | 22.36 | 22.33 | 54 | 22 | 19.20 | 18.28 |
| 18 | 19 | 16.14 | 15.97 | 55 | 22 | 17.88 | 17.27 |
| 19 | 20 | 14.90 | 16.03 | 56 | 21 | 17.50 | 16.50 |
| 20 | 21 | 19.38 | 19.10 | 57 | 21 | 20.56 | 19.46 |
| 21 | 21 | 20.12 | 19.45 | 58 | 21 | 17.46 | 17.05 |
| 22 | 23 | 14.26 | 13.46 | 59 | 23 | 15.76 | 15.10 |
| 23 | 20 | 14.27 | 13.77 | 60 | 22 | 18.93 | 18.22 |
| 24 | 20 | 19.37 | 17.31 | 61 | 22 | 16.71 | 15.67 |
| 25 | 21 | 18.81 | 18.37 | 62 | 21 | 14.03 | 13.08 |
| 26 | 21 | 19.46 | 18.21 | 63 | 21 | 16.88 | 15.92 |
| 27 | 24 | 17.65 | 17.11 | 64 | 23 | 15.64 | 14.98 |
| 28 | 21 | 17.78 | 17.03 | 65 | 22 | 18.83 | 18.18 |
| 29 | 23 | 15.39 | 15.37 | 66 | 22 | 18.85 | 17.64 |
| 30 | 20 | 18.26 | 17.67 | 67 | 21 | 15.33 | 14.71 |
| 31 | 21 | 16.09 | 15.55 | 68 | 21 | 17.71 | 15.69 |
| 32 | 21 | 17.56 | 17.02 | 69 | 21 | 17.05 | 17.33 |
| 33 | 22 | 21.92 | 20.57 | 70 | 22 | 17.08 | 16.69 |
| 34 | 20 | 15.97 | 15.48 | 71 | 21 | 14.71 | 14.43 |
| 35 | 21 | 16.46 | 15.94 | 72 | 21 | 15.40 | 15.05 |
| 36 | 21 | 14.60 | 13.94 | 73 | 23 | 14.97 | 14.76 |
| 37 | 20 | 20.62 | 18.64 | 74 | 21 | 14.80 | 14.22 |

Based on table 2, it is known that there were as many as 74 participants. The mean age of the subjects was 21.12 years (SD = 1.07). Participants ranged in age from 19 to 24 years. Participants consisted of 61 men and 13 women. Based on the description of the product trial data, it is known that the mean ± SD of conventional data (17.60 ± 2.30) seconds, and the mean ± SD of automation data (16.88 ± 2.17) seconds as can be seen in table 3.

Tabel 3 The Comparison of Product Trial Data Description

| | Hexagonal Obstacle Test | |
|---|---|---|
| | Conventional | Automation |
| n | 74 | 74 |
| Mean | 17.60 | 16.88 |
| Median | 17.44 | 16.71 |
| Standard Deviation | 2.30 | 2.17 |
| Range | 10.93 | 10.53 |
| Minimum | 13.11 | 12.93 |
| Maximum | 24.04 | 23.46 |
| Sum | 1302.72 | 1249.78 |

Table 3 also shows that there is a comparison of the minimum (13.11) and maximum (24.04) values obtained from conventional measurements with the minimum (12.46) and maximum (23.46) values obtained from automatic measurement.

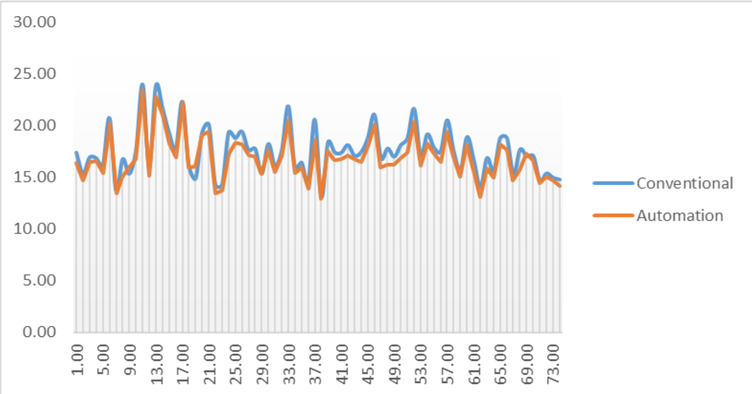


Figure 5. Comparison of Product Validity Data

However, figure 5 also shows how the difference in travel time is between conventional and automated hexagonal obstacle test agility measurements. It can be seen that most of the travel time is conventionally longer than the automation travel time. The external validity of the product is done by correlating the agility measurement data with the stopwatch and the hexagonal obstacle test automation product obtains a value of 0.975146897.

The data from the agility test using the hexagonal obstacle test automation were divided into two groups odd and even. Between the odd and even groups were analyzed and the product-moment correlation value was 0.992766989. This value indicates that there is a correlation, the direction is positive, and the correlation index is large because it is close to number one. Furthermore, the product-moment correlation value was tested with the Spearman-Brown (Split Half) split technique and the reliability value was 0.995983936.

## 4. CONCLUSIONS

Based on the results and discussion that has been described, it shows a conclusion that the hexagonal obstacle test automation product is valid and reliable for measuring agility. Hexagonal obstacle test automation products also provide more objective measurement results. This is due to a lack of agility measurement using a conventional hexagonal obstacle test using a stopwatch. The disadvantage of conventional measurement is that the measured subject does not start correctly at the same time as the tester pressing the stopwatch start button on the start signal. So that the travel time generated by the conventional measurement is not objective.

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