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Original Scientific Article

The Development and Validation of a Low-Cost Timing Gate Prototype as an Alternative to a Stopwatch in Agility Testing

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Background. Agility, defined as the physical attribute that enables individuals to swiftly alter their direction, is assessed through various tests, including body type assessments and sport-specific evaluations. It encompasses rapid alterations in the entire body, movements, and limb orientation. Agility plays a pivotal role in sports such as basketball, soccer, and racquetball, where prompt directional changes and precise body control are indispensable. Notably, the 505 test stands as the most reliable agility test, exhibiting a correlation with acceleration but not with speed. It monitors both speed and agility development. However, the prohibitive cost and accessibility challenges associated with the timing gate technology in Indonesia restrict its widespread application. Consequently, local sports practitioners continue to employ conventional stopwatches for their assessments.

Objectives. The objective of this study was to develop a low-cost timing gate prototype that will be validated and approved by local users in Indonesia. The study evaluated the agreement between the 505 Agility Test measures, which utilize a stopwatch and a timing gate device that was constructed by the authors of the present study.

Materials and Methods. The test protocol was administered to 40 fifth-semester students (9 females and 31 males) from the physical education study program in Indonesia.

Results. The timing gate prototype was 0.19 seconds faster than the stopwatch measurement results ($p < 0.05$). The prototype has also demonstrated excellent reliability. The Intraclass Correlation Coefficient (ICC) was found to be 0.920, with a 95% Confidence Interval (CI) of 0.848–0.958. Bland-Altman plots revealed a good level of agreement with the prototype.

Conclusions. The findings indicate that the timing gate prototype is a potential replacement with a low cost for measuring timing results from conventional 505 agility tests using a stopwatch.

Keywords: 505 agility test, agility, timing gate, prototype.

Introduction

The physical ability to quickly change direction is known as agility (Lockie et al., 2003; Lockie et al., 2017; Spencer et al., 2005). Several types of tests can be used to measure the agility of an athlete, including a variety of body types and sport-specific tests (Firdausi & Simbolon, 2021). Agility was traditionally defined as the ability to change direction quickly and accurately, but some authors have defined agility as a change in the direction of the entire body as well as rapid movements and changes in the direction of the limbs (Sheppard & Young, 2006). Agility is the ability to change the position and direction of the body quickly and efficiently (Hoeger, 2008). Agility is a rapid change in the direction or speed of the whole body in response to an activity that requires a stimulus (Dawes & Roozen, 2012). Agility is one of the most commonly measured variables during athlete performance testing (Miranda et al., 2016). Agility is important in sports such as basketball, soccer, and racquetball, where participants must change direction quickly and also maintain proper body control (Hoeger, 2008). The 505 test is the most valid agility test because it produces the highest correlation with acceleration in the reverse phase of the test; however, this test is not highly correlated with speed (Sheppard & Young, 2006). The purpose of this test is to monitor the development of the athlete's speed and agility (Mackenzie, 2008).

The procedure for implementing the 505 agility test requires assistance in operating a stopwatch (Mackenzie, 2008). The innovation called the timing gate basically already exists, but this technology is still difficult for people in Indonesia to reach. The electronic timing gates (Witty Timer, Bolzano, Italy) for 2,012.4 pounds sterling was employed in earlier research (Balsalobre-Fernández et al., 2019; Stojanović et al., 2019). An electronic timing gate (PR1aW, Alge-Timing GmbH, Austria) with an accuracy of one hundredth of a second used in previous studies, costs 482.5 euros only for one part photocell (Hůlka et al., 2018). Another study measured agility using a Brower timing system (Brower Timing System, Salt Lake City, UT, USA) costing USD 1,358 (Spasic et al., 2013). The purchase price of this technology is expensive and must be imported from abroad, so sports practitioners still take conventional measurements using a stopwatch.

Although infrared distance measuring technology has been widely employed in a variety of scientific sectors, it is currently underutilized in the field of sports testing and assessments. Infrared sensors are currently being employed in the construction of measuring devices on a national scale (Pribadi & Haryono, 2011). The leg power measurement gadget that uses infrared technology has a high validity value and a very high reliability value, according to statistical calculations (Haryono & Pribadi, 2012). This demonstrates how infrared technology may be used and developed in sports testing and monitoring. The aim of this research is to create a low-cost timing gate product. So that this timing gate product can be accepted by local users, we tested its validity.

Materials and Methods

Study Participants

The sample consisted of 40 fifth-semester students (9 female and 31 male) from the physical education study program at in Indonesia. Ethical approval has been obtained from the review board of the research and community service institutions of Padang State University and Muhammadiyah University of Bangka Belitung. With number 02.01/KEPK-UNP/II. The sample understands well the procedures for carrying out the 505 agility test.

Test Protocol

The 505 agility test is used to assess an athlete's speed and agility when performing a 180-degree turn (Mackenzie, 2008). The following (Figure 1) is the procedure for performing the 505 agility test with the timing gate system: (1) Athletes line up 10 meters from the laser timing system sensor device at the starting line; (2) Athletes sprint from the starting line to the 10-meter line (using a laser timing system) (at this distance the athlete increases speed); (3) The timer will begin automatically when the athlete passes the laser on the 10-meter line; (4) The athlete runs to the 15-meter line (turn line), then circles back to the starting line; (5) The timer will automatically stop when the athlete passes the laser on the 10-meter line again; and (6) The time is recorded as a result of the 505 agility test. Meanwhile, measurements are carried out with a stopwatch operated by an experienced tester.

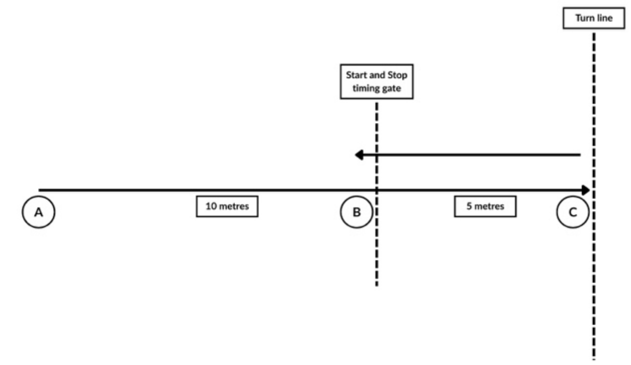


Fig. 1. The track of 505 agility test

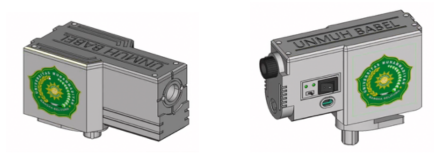
Data Collection and Analysis

We evaluated the agreement between the 505 Agility Test measures using a stopwatch that we utilized and a timing gate device that we constructed. Reliability between timing gate and stopwatch product readings based on the intraclass correlation coefficient (ICC) (Manson et al., 2014; Peebles et al., 2018). If the ICC value between measurements was greater than 0.50, the tested measuring device was considered to have appropriate stability; if it was greater than or equal 0.80, it was considered to have high stability (Rusdiana et al., 2021). A 0.9 ICC rating was considered excellent, a 0.9 to 0.75 value was considered good, a 0.75 to 0.5 value was considered moderate, and a value less than 0.5 was considered poor (Koo & Li, 2016; Peebles et al., 2018; Rusdiana et al., 2021). The paired t-test was performed to identify the two differences measurements mean performance (Parente et al., 2019; Perrotta et al., 2023; Rusdiana et al., 2021). A statistical tool called the Bland-Altman plot is used to compare two measurement methods (Alzahrani et al., 2015; Bravi et al., 2023; Hui et al., 2018). A Bland-Altman Plot can be used for this assessment (Bian et al., 2022). Bland-Altman analysis shows systematic error (bias) of the measurement results (Bruzzo et al., 2020; Gupta et al., 2009; Maeda et al., 2023; Stitt et al., 2021). SPSS (Version 26) was used for all statistical analysis, with significance set at 0.05.

Results

The laser-assisted 505 agility test instrument product is made according to the initial planning and design. The product is made up of several parts, including a laser transmitter and receiver (Figure 2), and a smartphone application (Figure 3).

The Transmission Control Protocol/Internet Protocol (TCP/IP) facilitates communication between sensor devices and applications on smartphones. The Transmission Control Protocol/Internet Protocol (TCP/IP) suite is a fundamental set of communication protocols that underpin



(a) (b)

Fig. 2. Laser Receiver (a) and Transmitter (b)

the Internet and private networks, including intranets and extranets (Feng et al., 2025). It consists of multiple layers, each with its own set of protocols, such as Wi-Fi, IP, TCP, and HTTP, which work together to facilitate data transmission (Alsahli et al., 2024). TCP/IP is designed to ensure reliable, ordered, and error-free data delivery between client and server (Moradiya & Popat, 2024). The signal is transmitted from the smartphone application to the sensor through the server, indicating that the sensor is prepared for operation. Upon the testee's commencement of jogging and upon crossing the ten-meter mark, the sensor transmits a signal to initiate timing via the server to the smartphone application. Similarly, when completing a 180-degree turn at the 15-meter mark and passing the sensor at the ten-meter mark, the sensor transmits a signal through the server to the smartphone application to halt and log the testee's time. The smartphone application presents time in milliseconds, seconds, and minutes. So that the outcomes of the testee's travel throughout the 505-agility test may be objectively assessed.

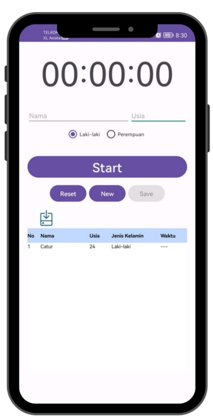


Fig. 3. The app display on smart phone

Table 1. The 505 agility test data description

	505 Agility Test	
	Stopwatch (Test 1)	The Prototype (Test 2)
n	40	40
Mean	3.15	2.96
Median	3.05	3.02
Mode	3.04	3.01
Standard Deviation	0.73086	0.55472
Range	2.97	1.99
Minimum	2.05	2.05
Maximum	5.02	4.04
Sum	126	118.64

Table 2 shown the timing gates product has excellent reliability (ICC = 0.920) on average measures with 95% Confidence Interval (CI = 0.848 – 0.958). Meanwhile, in single measures with 95% Confidence Interval (CI = 0.736 – 0.918) the timing gates product has strong correlation (ICC = 0.851). values between 0.75 and 0.9 indicate strong correlation or good reliability (Kerdaoui et al., 2021; Moradiya & Popat, 2024).

Table 2. The intraclass correlation coefficient

	Intraclass Correlation	95% Confidence Interval	
		Lower Bound	Upper Bound
Single Measures	.851	0.736	0.918
Average Measures	.920	0.848	0.958

Based on the findings of the investigation utilizing the paired t-test (Table 3), there is a significant difference (p <0.05) between the measurement results using timing gates product and stopwatch.

Table 3. The paired samples test

	Paired Differences	
	Mean	-0.18400
	Std. Deviation	0.35386
	Std. Error Mean	0.05595
95% Confidence Interval of the Difference	Lower	-0.29717
	Upper	-0.07083
	t	-3.289
	df	39
	Sig. (2-tailed)	0.002

Figure 4 shows Bland-Altman plots with bias of difference (mean diff = 0.184), upper limit (+1.96 SD = 1.750), and lower limit (-1.96 SD = -1.382). The Bland-Altman test results show good agreement between measurements. Inter-observer agreement tests on measurements of 40 samples between the prototype and stopwatch for 505 agility tests showed that there were differences in mean differences. However, a difference of >95% means it is still within that area (mean ± 1.96 SD). These results indicate that the use of timing gates prototype has a high level of stability.

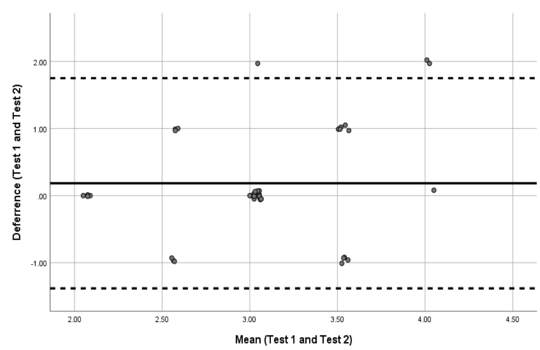


Fig. 4. The Bland–Altman Plots of 505 Agility Test Using Stopwatch (Test 1) and Timing Gate Prototype (Test 2)

Discussion

Based on the results of the paired t-test, differences were found between the measurement results using a stopwatch and the timing gate prototype. The timing gate prototype is 0.19 seconds faster than the stopwatch measurement results. We determined that a human mistake during the stopwatch operation during the 505 agility test was the cause of this. When compared between measurements using a timing gate and a stopwatch, it shows that measurements using a stopwatch have an average error of 0.17 seconds (Hribernik et al., 2021). The average measurement result using the prototype timing gate is 2.96 seconds. According to other studies, the average 505 agility test score was 2.7 seconds (Sonesson et al., 2020). The results of other studies show an average test result of 4.32 seconds (Stojanović et al., 2019). Differences in subjects influence differences in 505 agility test results, the criteria for agility measurement results must be adjusted to the characteristics of each subject.

The timing gates prototype has excellent reliability (ICC = 0.920), these results are in accordance with several previous studies. In 505 agility test measurements, prior research employing a timing gate (Browser TC Timing System, Biederitz, Germany) established an ICC = 0.85 (Kadlubowski et al., 2020). After assessing 505 agility tests using an electronic timing system (Microgate, Bolzano, Italy) and a test-retest method, it was discovered that ICC = 0.80 (Kerdaoui et al., 2021). Similarly, reported ICC of 0.92, 0.82, and 0.88 (Bakalár et al., 2020; Hopper et al., 2017; Sonesson et al., 2020). Lastly, there is a great degree of stability when using a timing gate prototype. The Bland-Altman test results provide good agreement across measurements, and the mean discrepancies between the prototype and stopwatch for the 505 agility tests are shown in the inter-observer agreement tests, suggesting strong stability.

Conclusions

A potential alternative for assessing the results of time records from the 505 agility test is the timing gate prototype. The timing gate prototype exhibited a time difference of 0.19 seconds, illustrating the capacity of the measurement data to generate more objective outcomes. Furthermore, the utilization of local manufacture and components confers a cost advantage to the prototype in development.

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Conflict of Interest

The authors declare there is no conflict of interest.

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Розроблення та валідація бюджетного прототипу часового селектора як альтернативи секундоміру при тестуванні спритності

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 6 с., 3 табл., 4 рис., 39 джерел.

Історія питання. Спритність, що визначається як фізична властивість, завдяки якій людина може швидко змінювати напрямок руху, оцінюється за допомогою різних тестів, включаючи аналіз типу статури та визначення специфічних для виду спорту показників. Вона передбачає швидку зміну положення всього тіла, рухів та орієнтування кінцівок. Спритність відіграє ключову роль у таких видах спорту, як баскетбол, футбол та ракетбол, де необхідні швидкі зміни напрямку руху та точний контроль положення тіла. Слід зазначити, що тест 505 є найнадійнішим тестом на спритність, який демонструє кореляцію з прискоренням, а не зі швидкістю. Він контролює розвиток як швидкості, так і спритності. Однак висока вартість та проблематика доступності, пов'язані з технологією часового селектора в Індонезії, обмежують широке застосування зазначеної методики. Як наслідок, місцеві фахівці у галузі спорту продовжують використовувати звичайні секундоміри для проведення аналізу.

Мета дослідження. Метою цього дослідження було розроблення бюджетного прототипу часового селектора, що проходитиме валідацію та випробовування місцевими користувачами в Індонезії. У дослідженні проведено оцінку узгодженості між показниками тесту 505 на спритність, для якого використовуються секундомір і пристрій часового селектора, сконструйований авторами представленого дослідження.

Матеріали та методи. Протокол тестування застосовано до 40 студентів п'ятого семестру (9 осіб жіночої статі та 31 особа чоловічої статі), які навчалися за програмою фізичного виховання в Індонезії.

Результати. Прототип часового селектора був на 0.19 секунди швидшим за результати вимірювання секундоміром ($p < 0.05$). Прототип також продемонстрував високу надійність. Коефіцієнт внутрішньокласової кореляції (ICC) становив 0.920, з довірчим інтервалом (ДІ) 95% від 0.848 до 0.958. Діаграми Бланда-Альтмана показали хороший рівень узгодженості з прототипом.

Висновки. Результати дослідження свідчать, що прототип часового селектора є потенційним бюджетним замінником для вимірювання результатів часових показників у стандартних тестах 505 на спритність із використанням секундоміра.

Ключові слова: тест 505 на спритність, спритність, часовий селектор, прототип.

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