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Original Article

A comparative study on measuring running speed using timing gates and stopwatches to reduce human error

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Abstract:
The purpose of this study was to determine the effectiveness of using an infrared camera-based running sensor to measure running speed in athletes and compare it with a stopwatch. With the hope of being able to answer the problems that occur in running sports related to the accuracy of the speed measuring device. The research method used in this research is quantitative. The sample used in this study consisted of 20 Indonesian trainers (aged 25–35 years) from various sports. The sample used was obtained from the entire population. The field scheme used in this study can be described as follows. The participants will take turns being asked to do the Illinois (8 Run for Measure Ability and Agility) to collect data using an infrared camera and a stopwatch; data was collected in the form of time that was successfully measured by the participants. Then, T run and short distance (10 m) run are performed. Based on the results of the research that has been done, it is known that the highest distribution of data in the three components measured indicates that the measurement with the stopwatch method is greater than the measurement with the infrared method, or the use of an infrared-based sensor camera. higher accuracy than the stopwatch method in measuring running speed in the T run, Illinois, and the 10 m dash. Thus it can be concluded that the use of an infrared-based sensor camera has higher accuracy than the stopwatch method in measuring running speed. These results are expected to have a positive impact on the sports industry in the future.
Keywords: **Running Sensor, Measurement, Infrared Camera, and Stopwatch**

Introduction

During this century, people have lived with various forms of sophistication as a result of technological development. It is undeniable that technology can improve various areas of human life, making it easy to perform every aspect of life, including in the field of sports. Imbach et al., (2020) have explained that it has been more than a decade that technology has entered the sports environment. It is gradually becoming an integral part of the sporting environment due to the positive integration of athletic talent with the artificial intelligence technology to achieve the best sports results (Cortsen & Rascher, 2018). Mali (2020) said that although the true nature of sport lies in the skills of talented athletes, their performance can be significantly improved by incorporating technology into the training process because technology itself has a huge capacity to improve their performance. One of the ways is through data analytics features that can finally provide insights about the performance of athletes, improve their training methods and skills through various advances and modern applications, and reduce any mistakes in both training and sports competitions.

Rathonyi et al., (2018) explains that there are at least three reasons why technology has become integral to the world of sports. Sports scientists can take advantage of computer science services in special technology fields such as data handling and software development, for training documentation, controller sensors, and data visualization. It is important to pay attention to innovations in sports especially in training and competition. The existence of new technological assistance helps open the horizons of sports experts in developing and solving all problems in sports. All three technological approaches and perspectives must be applied to the field of sports science. For example, the concept of soft computing can support the understanding of phenomena in sports.

One form of technology that is recognized to have a big role and contribution in the world of sports is infrared technology. Rathonyi et al., (2018) argues that the use of sensors, such as infrared sensors, in the world of sports has been discussed since the 1970s at a congress conducted by the International Organization for Sports Information (IOSI) until finally the infrared technology was applied in the world of sports to various fields such as sports medicine, sport physiology, sport biomechanics, and coaching. Its application in sports science makes infrared technology increasingly popular in the sports environment, especially in the field of coaching in the sport of running.

Infrared technology has been widely implemented, one of which is to measure running speed (Hidayat et al., 2019; Mugiyo Hartono, Andry Akhiruyanto, 2017; Romão et al., 2021). The development of a technology-based running speed measuring device has actually been implemented not only based on infrared technology but also based on a stopwatch which was already known and used much earlier. However, using a stopwatch to

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measure a runner's speed has several drawbacks; In particular, the results are estimated to be inaccurate, many individuals are required in measurement activities, there are different individual sensitivities, and data processing takes a long time, besides that there is human error which is the most common error when measuring stopwatch-based speed (Jr & Coe, 2013; Oh et al., 2019; Rahmat et al., 2016; Rusdiana, 2016). Z. Chen et al., (2021) even explained that the use of a stopwatch in measuring running speed should be avoided because it can cause a sizable bias in the measurement.

Despite all abovementioned weaknesses, the use of stopwatches in both training and competition activities is still often used. The results of research conducted by Z. Chen et al., (2021) suggest that stopwatches are extensively used because the tool is readily available and has a low price. Oh et al., (2019) further stated that the use of a stopwatch is still high because in addition to being readily available and economical, the tool is also considered simple, comfortable to use, and most importantly it does not require professional training to use; thus, it can be used by all groups. Therefore, in previous studies, researchers took the initiative to develop a running speed measuring device based on renewable technology with cheaper price. The tool is the infrared sensor camera.

Referring to these problems, a more accurate tool is needed to measure running speed with high validation but economical value so that it can be affordable by many people. The existence of these problems, made researchers take the initiative to develop a running speed meter based on renewable technology at a more affordable price, flexible, and can be used in various conditions. The tool is an infrared sensor camera (how to develop it is not discussed in this study). Furthermore, to ensure that the tool developed is highly validated so that it has the right accuracy in measuring running speed, researchers conducted tests to see the effectiveness of using a running speed measuring device in the form of an infrared camera sensor (to be discussed in this study).
Referring to the abovementioned explanation, the aim of this study is to test the effectiveness of the running speed measuring device in the form of an infrared camera sensor, which is expected to be able to address the problems that occur in running sports related to the accuracy of speed measuring devices. An effectiveness test will be performed by evaluating the accuracy of data from two running speed measuring devices (stopwatch and infrared). The tests that will be measured are Illinois, T run, and sprint (10 m). The time generated by the two measuring instruments is a component that will be used as the focal point of measurement to evaluate the effectiveness of the measuring instrument.

The effectiveness of the use of infrared technology in measuring movement speed has actually been tested first by (Chambell & Sayers, 1984), which is a study conducted by the Federal Highway Administration (FHWA) at the Southwest Research Institute. Infrared sensor has been also evaluated for the possibility of being used in vehicle-based systems to measure road surface profiles and high-speed track depths. Chen et al., (2015) have also conducted research on the effectiveness of infrared technology in measuring sports activities, especially running; although this research only focuses on one measurement tool. Finally, the results of research related to the effectiveness of using infrared in measuring running speed were performed by Rusdiana, (2016) aiming to develop software and hardware to measure running speed using a microcontroller with a personal computer interface. Similar to Chen et al., (2015), this research only focuses on testing the effectiveness of the tool without a comparison tool. This is the second reason for the development of a running sensor based on an infrared sensor. The adoption of this research objective is the reason behind the development of infrared-based sensor devices in the world of sports, especially the running sport, which still requires a deeper study.

Materials and methods

This study is quantitative research conducted to evaluate the effectiveness of the tool developed in the form of an infrared camera sensor. The research was performed by comparing the measured time when using two running speed measuring devices (infrared and stopwatch) for T run, Illinois, and sprint (10 m). The analysis was performed by evaluating the average difference between the three data sets obtained using both devices (infrared and stopwatch). The sample used in this study consisted of 20 Indonesian coaches (25–35 years old) from various sports. The sample used is taken from the entire population.

Instrument

This study uses a stopwatch and an infrared sensor as a research measuring instrument. The standard used to determine the timeliness of measurement is the standard that has been used in previous studies. In accordance with the measured components, in this study, standards that are used as a reference include agility tests according to sports branches in terms of basic motor characteristics: for Illinois, from Ucan, 2020; for T-run from Pauole et al., 2000 based on the research with the title of “Reliability and Validity of the T-Test as a Measure of Agility, Leg Power, and Leg Speed in College-Aged Men and Women, and Standard”; Majumdar & Robergs, 2011 with the title of “The Science of Speed: Determinants of Performance in the 100 m” is used for 10 m sprint.

In accordance with the measured components, (T run, Illinois, and sprint 10 M) in this study there are standard standards that are used as references to be used in measuring these three components. first T run. To measure it, the researcher used an infrared camera sensor, while to see whether the participants were able to run at a speed that met the standards or not, a standard instrument was used from the results of the research written by Paulole et al., 2000 with the research title Reliability and Validity of the T-Test as a reference. Secondly,

Illinois, to measure it, the researcher used an infrared camera sensor, while to see if the participants were able to run at a speed that met the standards or not, standard instruments were used from the results of a study written by Ucan, 2020, with the research title Ffor Illinois. For the three sprints, the researchers used an infrared camera sensor to measure them, while to see if the participants were able to run at a speed that met the standards or not, standard instruments were used from the results of a study written by Majumdar & Roberts, 2011, with the research title The Science of Speed: Determinants of Performance in the 100 M. This study uses a stopwatch and infrared sensors as measuring instruments to measure Illinois, T-run, and sprint (10 m).

Procedure

The purpose of this study is to test the effectiveness of running speed measuring devices to improve running speed measurement activities that are still performed using a manual system. The objective is to perform this measurement using a renewable technology system. Thus, this system can make it easier for users (such as athletes, judges, and coaches) to perform their activities both in training and competitions. The field scheme used in this study can be described as follows. The participants take turns being asked to perform Illinois (Fig. 1) (to collect data using an infrared sensor and a stopwatch), followed by a T-run and a sprint (10 m) (Fig. 2).

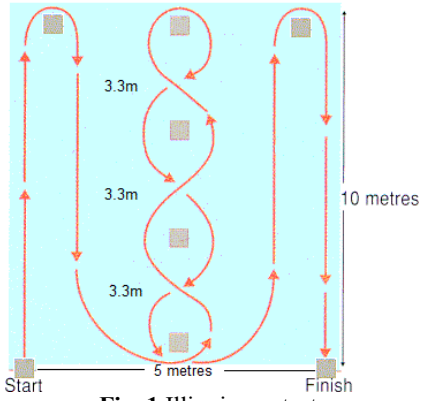

Fig. 1 Illinois run test

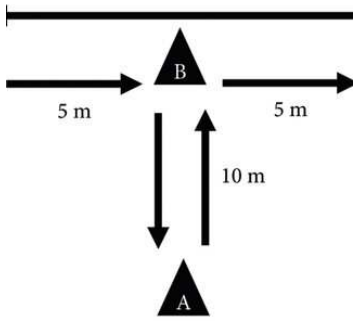

Fig. 2 T-run test and sprint 10 meter

First, as soon as the participants enter the test area, their running speed will be immediately measured. Two participants will run using the Illinois technique to test agility (up to 10 m), followed by a T-run (5 m to the right and 5 m to the left), a 10-m run to test the speed, and immediately exit the gate at the same location where they entered the area. As soon as the participants exit the area, the sensor camera will stop measuring the movement of the participants

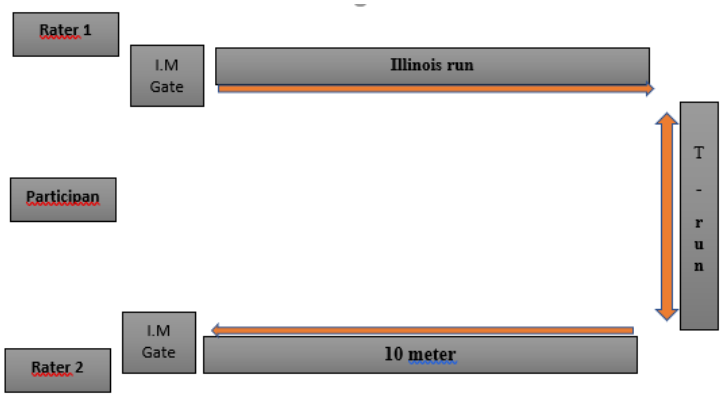

Fig. 3 Combination Illinois test, T-run test, and sprint 10 M test in this Research

First, as soon as the participants enter the test area, their running speed will be immediately measured. Two participants will run using the Illinois technique to test agility (up to 10 m), followed by a T-run (5 m to the right and 5 m to the left), a 10-m run to test the speed, and immediately exit the gate at the same location where they entered the area. As soon as the participants exit the area, the sensor camera will stop measuring the movement of the participants

Steps For Implementing Research Data Collection

First, participants enter the tool test area, they will immediately measure the participant's running speed. Both participants will run with the Illinois method to test agility (a distance of 10 meters).), followed by a T-run (5 meters to the right and 5 meters to the left), finally followed by a 10 meter run. to test the speed, and immediately exited the gate at the same location they entered the area from. As soon as the participant leaves the area, the sensor camera will stop counting to measure the participant's movement while inside the gate.

Results

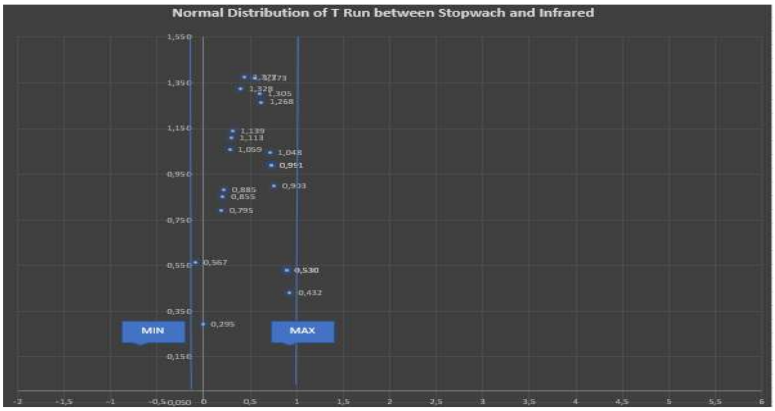

Fig. 4 Graph of the Normal Distribution of the T-run for the Stopwatch and Infrared Methods

Based on the research results (Fig. 1), it was found that there is a difference between the infrared and stopwatch measurement methods, which can be found in the distribution of the data at the point where the value of both is the same. This point is called the meeting point between the two methods, which means that there is no difference in the measurement value between the infrared and stopwatch methods.

Based on the results (Fig. 4) of the t-run, the reference point for the intersection of each data value is point 0 on the x-axis. This estimation is done by evaluating the difference between the two; then, the value of the difference is determined by the distribution in the data group. The abovementioned data shows that most of the data values are positive, which means that the measurement using the stopwatch method requires more time than the infrared method. Although there are two data values that show that measurements using the infrared method are greater than those using the stopwatch method or are in a negative x-axis value distribution, the data values show a very small distance to the point value of 0 as a meeting point; thus, it can be concluded that the difference measurements for the two methods are only slightly different.

There are two data values which indicate that the measurement with the infrared method is greater than the stopwatch method or is on a negative x-axis distribution, but the data values show a very small distance from the 0 meeting point. so that it can be obtained that the measurement price with the two methods is only very slightly adrift. this shows that the infrared method still provides more accurate measurements than the stopwatch even though the distance is very thin.

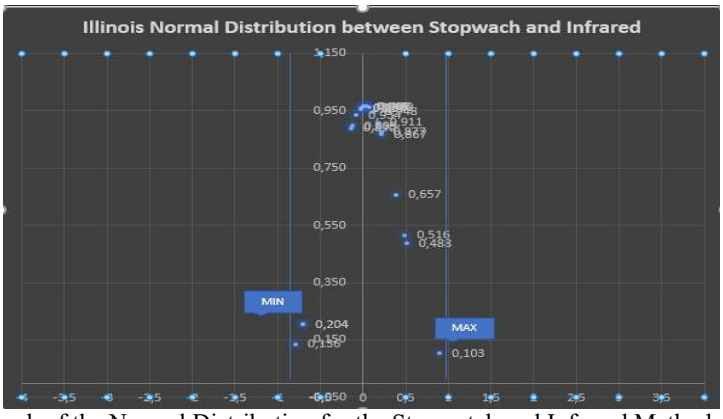

Fig. 5 Graph of the Normal Distribution for the Stopwatch and Infrared Methods

The distribution (Fig. 5) of the Illinois data using the infrared and stopwatch methods shows that most of the data point values are positive with a value range of 0–0.5 s with most of the values in that range approaching the point value of 0. However, three values exceed 0.5 s; one value in positive and two values are negative, which means that two measurements using the infrared method show a larger measurement than the stopwatch method. However, the distribution of data showing that infrared measurements are greater than stopwatch measurements is less than that of the infrared method.

Most data distributions show that the stopwatch method is larger or positive compared to the infrared data distribution. There are two measurements that are negative and away from point 0. Thus, it is necessary to perform an in-depth research to determine whether this large range difference is caused by pressing the stopwatch button faster, pressing the stopwatch button slower, or because there is an infrared sensor accuracy factor. Data points that are located away from the main distribution of this data group are called outlier data; thus, it is necessary to conduct in-depth research to determine the factors that result in the outlier data.

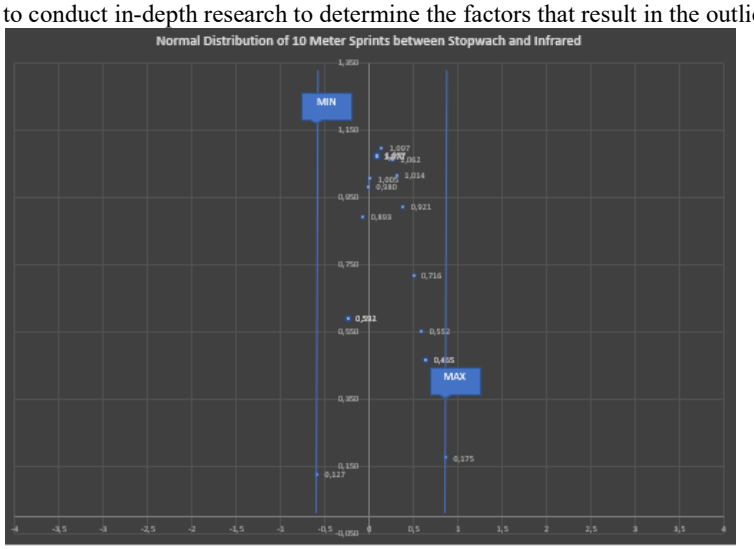

Fig. 6 Graph of the Normal Distribution of T Run between the Stopwatch and Infrared Methods

Based on the distribution (Fig. 6) of difference between the stopwatch and infrared methods for the 100-m sprint, it is observed that the distribution of most data is positive with a difference of 0–0.5 s. In addition, some data points are greater than 0.5 s in the positive area to the 0 s point, which is greater than the data in the negative area. The distribution of most of these data points shows that the measurement using the stopwatch method is greater than the measurement using the infrared method for the 100-m sprint. There is a delay in measurements made using the stopwatch method compared to the infrared method; thus, the distribution of the difference between the two methods is positive. One outlier data approaches the value of 1-s difference in the positive area and shows a fairly large difference value.

Discussions

The research results showed that the distribution of most values for the three measured components using the stopwatch method was greater than that using the infrared method. This result shows that the infrared sensor tool has sufficient consistency for measuring running speed compared to a stopwatch.

These results agree with research conducted by Neville et al., (2011) on the comparison between two measuring instruments for testing the running speed of an athlete in an open field. Their results show that a stopwatch has a measurement accuracy with lower validation than an accelerometer in the 50-m run test. Oh et al., (2019) further explained that the lack of measurement accuracy of the stopwatch caused a bias in the measurement results, one of which was due to the reliability between intra-appraisers when taking measurements. This also occurred in our study, where several outliers were found in the results of the Illinois measurements and 10-m sprint. Problems related to time accuracy of the stopwatch when measuring running speed were also explained by (Mistar, 2020). The results of his research were explained by the weakness of the stopwatch when measuring running speed during the training process, which affected the achievement of target or exercise goal.

Conclusions

Based on the research that has been done, it can be concluded that the infrared sensor camera has higher accuracy compared to the stopwatch method when measuring running speed. This is proven based on the results of tests that have been carried out, where the highest distribution of values for the three components measured using the stopwatch method is greater than using the infrared method. These results indicate that the infrared sensor has sufficient consistency to measure running speed compared to a stopwatch. This is a new result that is

expected to have a positive impact on the sports industry in the future, especially in running. Apart from that the results of this test show that the role of technology plays an important role in the development of the world of sports.

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