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# Development of Motion Sensor Device for Athlete Posture Assessment During Ergometer Rowing Machine Training

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**Abstract**: This project aims to use electronic components for indoor sports. Electronic components include sensors and microcontrollers. The sport of rowing was chosen to make this project a success because rowers are very active in training at the residential college. Almost every evening we can see rowing athletes doing rowing machine exercises to strengthen themselves with rowing. As an experienced athlete, it is no problem to do this exercise. Beginner athletes have difficulty starting the training because they do not know the correct body posture when doing this rowing exercise. This project is to examine and evaluate the athlete's body posture while doing this exercise. There are several types of techniques in this rowing exercise that will be an experiment to make the sensors able to detect the posture of the athlete's body. This project works by using sensors such as IR and Ultrasonic sensors. This sensor works to detect the presence of the athlete's body during training. The controller used is Node MCU and Arduino Nano and the LED serves as an indicator to know whether their body posture is good enough or not. The athlete just needs to sit down and pull the handle while straightening the legs. The correct body structure is that the athlete needs to straighten the body while bringing the hands close to the chest and straightening the legs.

**Keywords**: Indoor rowing, Good Posture, Poor Posture

## 1. Introduction

The movement and posture of the human body can be evaluated performance during sports activities is very important to get the necessary data and avoid injuries. There are also many types of rowing exercise machines on the market now but most of them only focus how to exercise rowing. This rowing exercise requires proper training to get the correct training position. When making random observations,

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novice athletes are not very confident about taking up the sport. It is a step to improve sports performance at UTHM as well as implementing electronic components.

Currently, rowing has grown rapidly among school and university students. Some of them are so excited that they forget to take care of their body position to get injured. These new athletes have a hard time figuring out how to get used to this rowing exercise. A correct body posture assessor will be able to provide stable and accurate rowing training while preventing injuries. Research about the actual technique of doing this rowing exercise is very important in this regard because from the correct technique, we will be able to find out where the sensor reading should be looked for. Several body parts need to be considered to determine the correctness of the exercise. This can make it easier for them to become professionals in rowing. The correct technique can prevent the beginner athlete from easily getting injured thus making the exercise an effective exercise.

Electronic components will be applied to the rowing machine so that rowing machine users can evaluate their performance during exercise. The sensor will be used to function as a body movement sensor, the position of the rowing machine seat and some handle positions. All these sensors will be controlled by Node MCU and Arduino Nano. According to the initial planning of this project, 2 types of sensors will be used to determine the accuracy of using this rowing machine. Athletes only need to modify the sensitivity to suit their height. This needs to be done to ensure that the sensor can detect correctly according to the athlete's height. Beginner athletes who have just tried this sport will feel a significant effect because the correct technique posture in this project can make an athlete look professional. Professionals are not the main purpose of this project, but its effectiveness helps beginner athletes to do this training in the initial phase.

### 1.1 Good Posture and Poor Posture for Indoor Rowing Exercise

Exercise rowing has certain techniques namely catch, drive, finishing and recovery. These techniques must be done in the right way to ensure body posture is in the right condition. The presence of certain sensors can make the correct rowing technique possible for new athletes. Figure 1 shows an experienced athlete performing a catch technique at the left side. This catch technique is the starting technique for exercise rowing. First, the arms should be straight while the head should be neutral. The shoulders are level and not bent. The upper body leans forward from the hips with the shoulders in front of the hips. The legs are vertical, or as close to vertical as is comfortable for you. Shins should not move past the perpendicular. The heel can be raised as needed. The aspect that will be measured using the ultrasonic sensor here is on the leg. The leg should be at a 45-degree angle.

On the right side on the figure 1 above shows an amateur athlete with a wrong posture when doing the catch technique in rowing training. This athlete is doing the catch technique incorrectly. The athlete's arms should be straight forward while his head is not straight. The most obvious mistake is the condition of the legs of the upper body. The position of the athlete's feet should be vertical or close to vertical indicating a 45-degree angle opening. The athlete's upper body should be vertical and without pressure. Sensors will be placed in this technical part in the right place to help the athlete perform the rowing exercise safely and correctly.

**Figure 1: Good and poor posture for catch technique for indoor rowing exercise.**

Figure 2 shows the experience athlete doing the indoor rowing exercise finishing technique on the left side. For this finishing technique, the upper body should lean slightly backwards. This part of the technique is measurable. By using good support from the core muscles. Legs are extended and straightened. Shoulders should be low with wrists and grip relaxed. The wrist should be level with the handle. The handle is held lightly under your ribs. This handle should be close to the bottom of the rib and can be measured using a sensor.

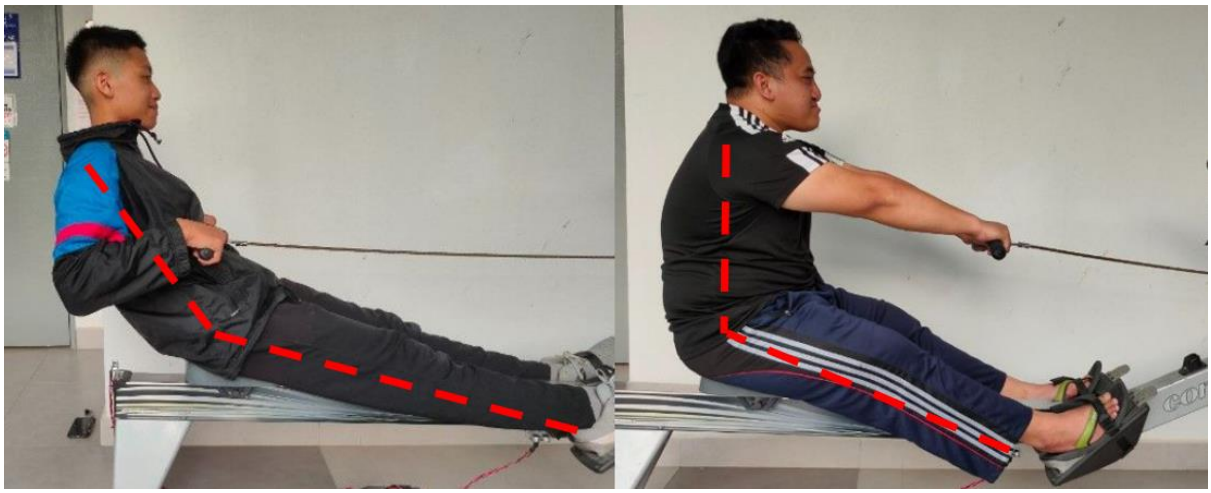

**Figure 2: Good and poor posture for finish technique for indoor rowing exercise.**

On the right side of the figure above, shows an amateur athlete who performs the finishing technique in the rowing exercise in the wrong way. The first aspect that can be seen is that the athlete's body does not lean slightly backwards. This amateur athlete just straightened his body. This can be considered as one of the ways to correct the condition of this amateur athlete. A sensor will be placed on the back of the athlete's body so that the athlete knows how far he should push using his legs and upper body lean slightly backwards. The athlete is not holding the handle in a right way. The handle should be pulled so hard that it touches the lower part of the athlete's chest, causing this athlete's rowing

training to be bad. There is a gap between the handle and the lower part of the athlete's chest. A sensor can apply to the handle to detect the density of the lower part of the athlete's chest.

## 2. Materials and Methods

This section provides a thorough overview of the methods and materials used in this project. The information will include all aspects related to the work procedures for each stage, namely, block diagram, software and hardware used, and the overview of the system flowchart.

### 2.1 Materials

The design of this project was made based on its functionality as a monitoring body posture while doing the rowing exercise. Therefore, the components in this project will be attach to the rowing machine. However, the position of the components is very important so as not to interfere with the athlete's movement while doing rowing exercises on the ergonomic rowing machine. To get good body posture, the ultrasonic sensor will be used to measure the distance between the athlete's body and the sensor. These distances are studied and researched to be suitable for beginner athletes. Infrared sensors are also used to detect the human body in this project. The use of infrared sensors is not as complex as ultrasonic. The data taken is studied from the movements of experienced athletes. The data is important for setting the program code. The list of components and software used for this project are listed below:

- Node MCU ESP32
- Arduino Nano
- Ultrasonic Sensor
- Infrared Sensor
- Buzzer
- LED
- Lithium-Ion 18560 Battery
- Arduino IDE
- Proteus

Figure 3 below shows the general block diagram on how this project works. The signal from the ultrasonic sensor 1 will be transferred to Node MCU 1 by wired and the signal from the ultrasonic sensor 2 will also be transferred to Node MCU 1 by wired. Signal from IR sensor will also be transferred to Arduino Nano by wired. Node MCU 1 will process the signal obtained from the sensor and will illuminate the LED either red or green. Ultrasonic sensors 1 and 2 are input in this project. Arduino nano and Node MCU esp32 act as a microcontroller that will control all the programs in this project. There are 2 types of output indicators, buzzer, and LED. The LEDs used are red, blue, and green. Red LED will show poor posture, blue moderate posture, green bad posture. Esp32 uses both types of output indicator which is buzzer and LED. Arduino nano uses only one type of output indicator which is buzzer.

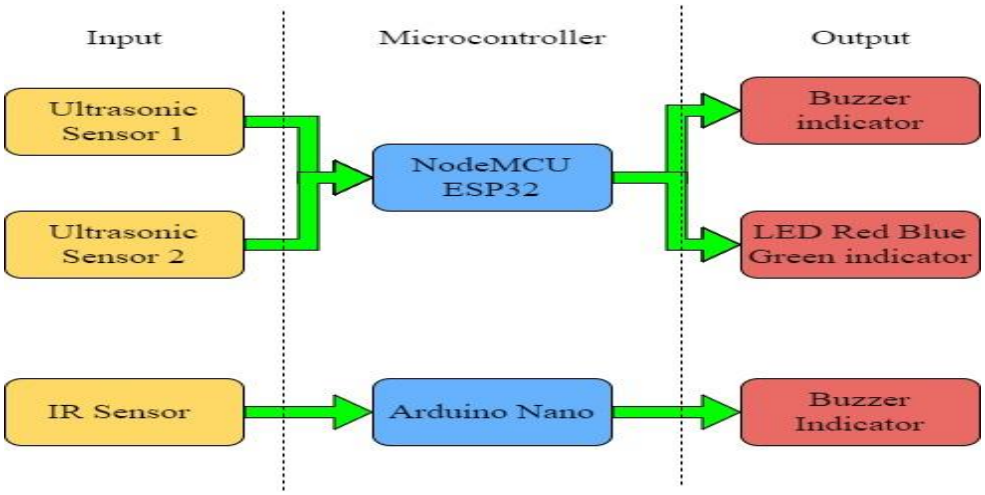


**Figure 3: Block diagram of the system**

The position of the sensor is very important in the production of this project because with the correct position, it can work well and can take the necessary data. Incorrect component positioning can result in a lack of accuracy in the detection of the sensor used. The position of the sensor is selected based on its non -interference with the exercise performed on the rowing machine by the athlete and does not interfere with the athlete to perform the exercise.

Figure 4 below shows the position of the sensor that will be applied in the rowing machine. The IR sensor 1 will be placed on the handle of the rowing machine to detect the athlete's chest whether it is closest to the handle during exercise or not. There is a microcontroller that will both be in the handle of the rowing machine. The ultrasonic 2 is placed at the bottom to detect the presence of the athlete's legs during this rowing exercise. The athlete's legs will be in a straight position when pulling the handle. Ultrasonic sensors 1 will be placed at the back to detect the distance taken by the athlete to push the seat while doing rowing exercise. Other components such as the microcontroller will be placed at the bottom of the machine. The more important thing is the best exercise can be obtained.

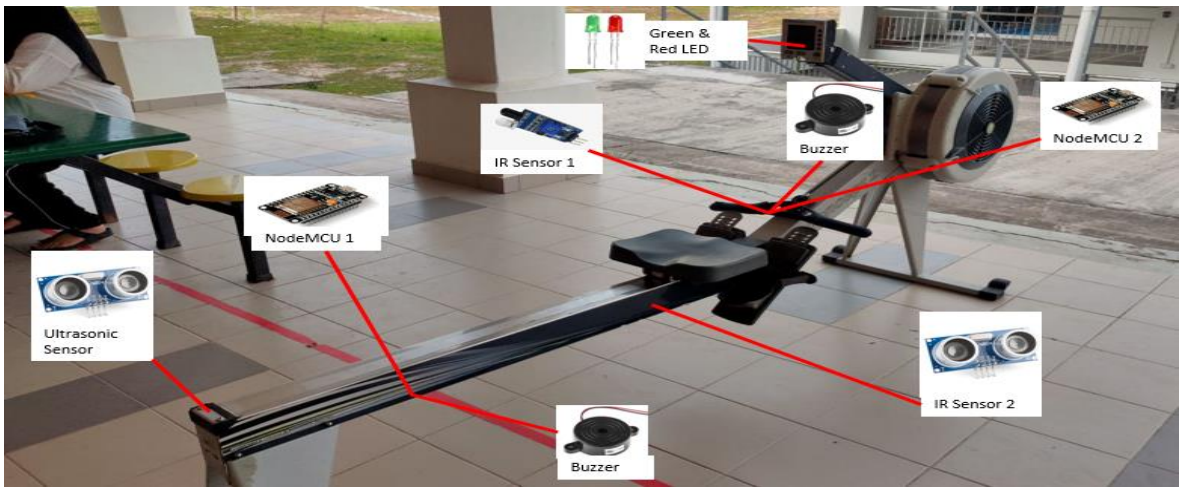


**Figure 4: Component placement on the rowing machine**

## 2.2 Methods

Under the title of this methodology, will discuss the ways to make this project a success. The information will cover all aspects of work procedures for each stage, including an overview of system flowchart, and hardware used, design architecture, and project advantages and disadvantages over previous projects evaluated in the literature review. The design of this project focuses on the accuracy

of sensors to detect the human body while performing rowing exercises. By using the relevant sensors, the sensor will provide an analog signal to the processor and the processor will process the data whether it has met the standards set for a good rowing exercise or not.

Flowcharts are very important for a project so that it is easy to see the flow of a project. A flow chart is a type of diagram that represents a workflow or process and can be defined as a diagram representation of an algorithm to complete a task. The representation of this diagram illustrates the solution model to a given problem. Flowcharts are used in analysing, designing, documenting, or managing processes or programs in a variety of fields. As the flow chart in the diagram below shows the flow of this project.

Figure 5 shows the system flow chart project journey that will be shown at the beginning to end. First, when athletes want to use this rowing machine, they should choose their height range by changing the position of ultrasonic sensor 1 at the back of the rowing machine. After they select, Athletes must sit in a ready state. Athletes can start their rowing training on the rowing machine. At the same time, the sensors will be functional and ready to detect the presence of the athlete body posture with thus technique. During the exercise, the athlete should straighten the legs, pull the handle up to the chest with straight hands and push the seat up to the proper distance.

When the athlete performs the catch technique correctly, the green led will light up along with the indicator buzzer. If the sensor does not detect programmed distance when detecting the presence of the athlete's body, the red LED will remain lights up. The LED function gives an indicator to the user that if the red LED is still on then their exercise is still not in good and correct condition. The green LED will light up to indicate that their body posture and rowing exercise performance is in good and steady condition.

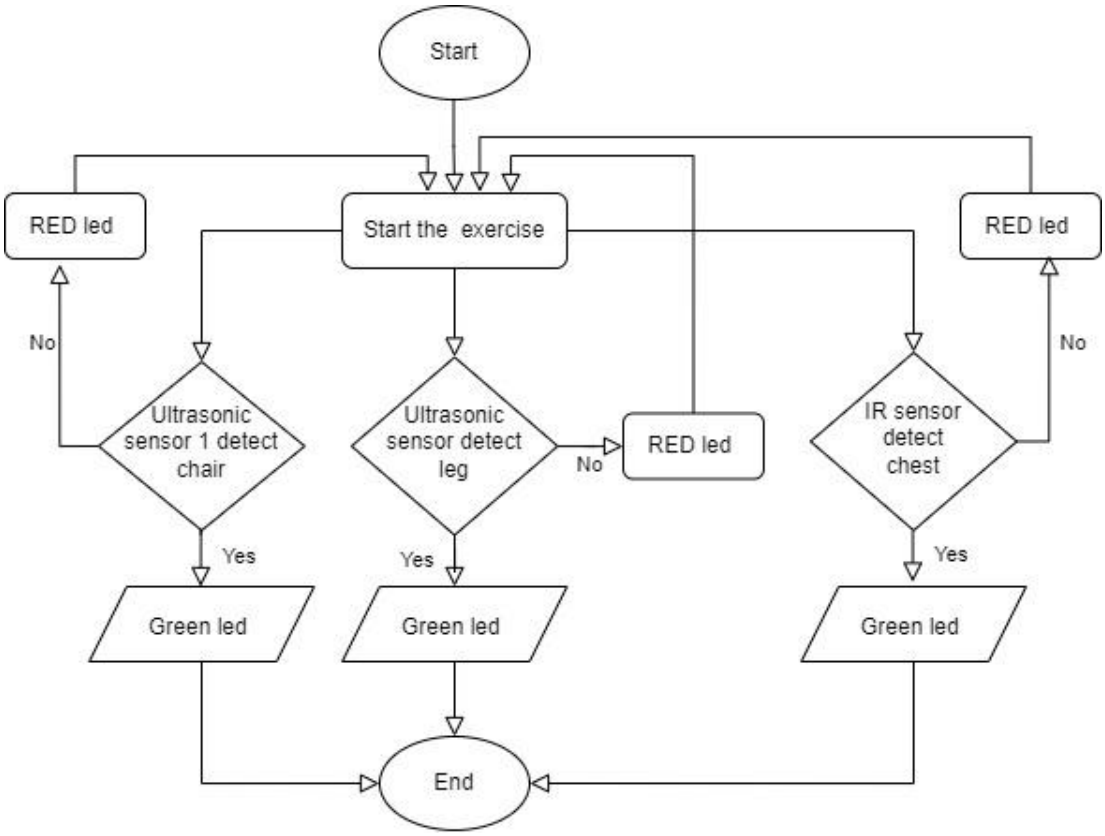


**Figure 5: System flowchart of the project**

## 3. Results and Discussion

This section focuses on the analysis and discussion of collected results and findings that was obtained from several experiments conducted with reference to the aims of the project. For this chapter, the development shows that the analysis from material selection, product design and process with simulation. Therefore, the purpose is to avoid any errors and mistakes during testing. The following details such as product sketches and engineering drawings have been guided as a reference for the testing process and technical description.

### 3.1 Final Product

The original product design has been selected in which the position of the sensors has been proposed in the methodology. The design needs to reflect through the actual dimensions of the existing rowing machine. All the processes involved were completed without any errors. The dimensions of the rowing machine have been considered to determine the length of the wire to be used. It is very important to determine the correct wire length because this project involves the movement of the athlete's body. If there is too much wire, the movement of the athlete's body will be disturbed and will affect the sensor reading.

Figure 6 above shows a rowing machine that has been fitted with a posture monitoring device. All wiring measurements done are accurate. The wires used can be connected neatly and well. There is no problem about how to install this device to the rowing machine. Next, the parts involved in this device will be shown one by one.


**Figure 6: A rowing machine that has been equipped with a motion sensor device**

Figure 7 (a) on the left shows the device on the handle rowing machine. This device is attached using a tight cable. The small black box is called the handle box. Inside the small black box is an Arduino Nano that works as a microcontroller. The microcontroller is connected to the infrared sensor as an input to detect the presence of the lower part of the athlete's chest when the athlete performs the finishing technique in this rowing exercise. Buzzer indicator is also included in the black box to indicate to rowing machine users that the brand has pulled the handle of this rowing machine correctly. All the components mentioned are powered by using a rechargeable 5V battery.

Figure 7(b) shows the microcontroller box is attached to the bottom of the rowing machine because it does not interfere with any movement during rowing training. This microcontroller box stores

node mcu esp32 which is powered using 5V battery energy type 18650. Ultrasonic 1 and ultrasonic 2 which act as input are connected using wire. Ultrasonic positions 1 and 2 will be explained in the next subchapter. Outputs such as led, and buzzers are also connected to the esp32 located in the microcontroller box.


**Figure 7: (a) Device on the handle rowing machine and (b) microcontroller box**

Figure 8 (a) shows on the left side shows the position of ultrasonic back on the rowing machine. Ultrasonic back is positioned at the back because it can detect the distance of the athlete's seat while performing the finishing technique. Figure 8 (b) shows the position of ultrasonic 2 on the rowing machine. Ultrasonic 2 is positioned at the bottom because it can detect the distance of the athlete's leg while performing the catch technique.


**Figure 8: (a) Ultrasonic sensor for the back (b) Ultrasonic sensor for the leg**

3.2 Testing and Analysis Data

This product testing process is very important to ensure its continuity runs smoothly. All data obtained is recorded and studied one by one to determine the appropriate distance range to use. Furthermore, this project involves human movement gestures, so it needs to be suitable for use by athletes of various heights. Data obtained by some experienced athletes can be used. The data can be considered as a result.

Table 1 shows the distance taken in centimeters between the ultrasonic sensor 1 and the chair when the athlete performs the finishing technique. From this finding, athletes who have a high height will make a longer push thus making the ultrasonic distance 1 with the seat closer. The difference between the ultrasonic distance and the seat taken during the finishing technique between 170cm and 175cm athletes was not significant. Only 0.4cm difference between them. Therefore, athletes with a height of 170cm and 175cm will share the same good posture range. The data from this finding can be used as a benchmark for the range that will be used for beginner athletes.

**Table 1: Distance that take from ultrasonic back to the chair from professional athlete**

| | Athlete's height | | |
|---|---|---|---|
| | 170cm(cm) | 175cm(cm) | 180cm(cm) |
| 1 | 23 | 25 | 18 |
| 2 | 21 | 20 | 18 |
| 3 | 22 | 20 | 18 |
| 4 | 23 | 23 | 19 |
| 6 | 23 | 22 | 19 |
| Average | 22.4 | 22 | 18.4 |

Table 2 shows the distance taken in centimeters between the ultrasonic sensor 2 and the chair when the athlete performs the catch technique. From this finding, the distance between the feet and the ultrasonic sensor for both athletes who are 170cm and 175cm tall is approximately. They can share the same sensor sensitivity range. For athletes with a height of 180cm, the distance between the sensor and the leg when doing this catch technique is closer. This is because the legs of the 180cm athlete have longer legs.

**Table 2: The distance from ultrasonic leg to the professional athlete's leg**

| | Athlete's height | | |
|---|---|---|---|
| | 170cm(cm) | 175cm(cm) | 180cm(cm) |
| 1 | 36 | 36 | 23 |
| 2 | 36 | 37 | 21 |
| 3 | 36 | 35 | 21 |
| 4 | 36 | 36 | 21 |
| 5 | 35 | 35 | 20 |
| 6 | 36 | 35 | 19 |
| 7 | 35 | 36 | 19 |
| 8 | 34 | 34 | 19 |
| 9 | 34 | 35 | 20 |
| 10 | 34 | 36 | 21 |
| Average | 35.2 | 35.5 | 20.4 |

Figure 9 shows the handle box being used by the athlete. As a result of the observation carried out during testing, all athletes close the handle of the rowing machine directly towards the lower chest. If you look back at the actual technique of doing this rowing exercise, during the finishing, the athlete pulls the handle close to the chest. Athletes of different heights do the same thing. It is concluded here that the IR sensor setting on the handle box will be set to a very low sensitivity. This very low sensitivity means that if there are objects that are really close, then this sensor will detect.

**Figure 9: Handlebar that already install with handle box have been pull**

3.3 Trial for beginner athletes using this device

Figure 10 shows a beginner athlete using a rowing machine that has not been contacted with the body posture monitoring device while doing the rowing exercise. Figure 10 (a) shows when the athlete does the catch technique, his legs are not close to the body so that his legs do not form a 45-degree angle. It can be concluded that this beginner athlete has not adapted to the correct rowing exercise. Figure 10 (b) shows that the beginner athlete does not extend his legs properly and leans the upper body slightly backwards while doing the finishing technique. The handle that the athlete is holding is also not close enough to the lower part of the chest. Overall, the posture style of this beginner athlete is poor.


**Figure 10: (a) Without sensor catch technique (b) without sensor finishing technique**

Figure 11 shows the same beginner athlete using a rowing machine that has been equipped with the final product and has been set to a suitable range for him. Roughly speaking, it looks like this athlete's style has begun to get used to the actual posture in exercise rowing. Figure 10 (a) shows the athlete in a state of catch technique. The green led indicator for the catch technique shows a green colour and the baby buzzer indicator shows that the athlete has done the catch technique well. His legs can already be seen starting to form a 45-degree angle.

The catch technique used by this beginner athlete resembles the technique of a professional athlete because the sensors work well to detect the presence of the athlete's body well. Figure 11 (b) shows this beginner athlete doing the finishing technique. The led indicator of the finishing part lights up green at the same time with a buzzer sound indicating the behavior of the finishing technique that is

done well. His legs which were not straight before are now straight and the upper body of this beginner athlete is slightly backwards. The handle that was pulled was also close to the bottom of the chest together with the indicator buzzer sounding.

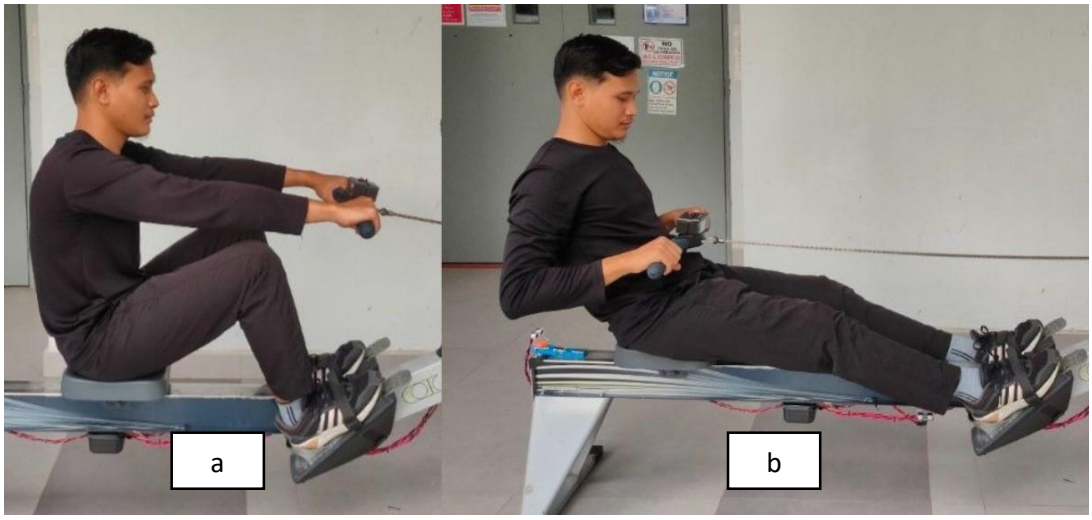


**Figure 11: (a) With sensor catch technique (b) with sensor finishing technique**

## 4. Conclusion

The problem of getting used to rowing machine exercise for beginner athletes can be overcome with this project. Beginner athletes do not need hard exercises and do not need to repeat many times to adapt to the correct exercises. With the presence of two types of indicators, namely led and buzzer, it can be a good alarm. The sensors used can also work well. Ultrasonic especially has a lot of impact on this project because it can measure distance accurately and quickly. When this beginner athlete performs the technique finishing scene, ultrasonic sensor back can accurately detect the seat distance.

Ultrasonic leg managed to accurately detect the distance between the feet and the sensor during the catch technique in this exercise rowing machine. Not to be forgotten is the IR sensor that detects the presence of the athlete's chest so that the athlete's posture during the finishing technique is good. Because manual training doesn't pay off quickly, this project is able to make athletes behave like experienced, skilled athletes. Athletes' stamina is the only thing that differentiates them whether they are experienced or not. This makes many UTHM students able to try this rowing exercise sport and bear fruit with new talent in this rowing sport.

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