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Digital Measuring Instruments for Height and Weight with Microcontroller-Based Sound Output

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ABSTRACT

Height and weight measuring devices simultaneously provide ideal weight information that will be handy for users. This study aims to provide an instrument that can be used as a measuring instrument for height and weight and whether or not a person's body is ideal. Therefore, in research, measuring instruments that can simultaneously measure height and weight and provide ideal information or not measured weight. This measuring instrument uses Arduino Uno as its brain, ultrasonic sensors to measure height, and strain gauge/load cell sensors to measure weight. Arduino processes data from both sensors to get the ideal body weight (BBI). The height, weight, and ideal body criteria values will be displayed on the LCD. Furthermore, the speaker will issue sound information regarding the condition of body weight, namely ideal, fat, or thin. Based on the testing and data analysis results, the average error percentage value in height measurement is 0.45%, and in weight measurement is 1.65%. At the same time, the success rate of the appearance of voice information is 99%.

Introduction

Humans still measure height manually using measuring instruments such as meters and rulers. This design will make a tool that will measure ideal height and weight automatically by utilizing a microcontroller as a controller of the tool to be designed (Afdali, Daud, & Putri, 2017). Measurement of height and weight in general has been done automatically; in this case, automatic measurements of height and weight are done using different tools (Nurlette & Wijaya, 2018). In addition, the measurement results of both height and weight have been read carefully by the sensor used (Kusriyanto & Saputra, 2016).

"Digital Measuring Instruments for Height and Weight with Microcontroller Based Sound Output," as the title. The intention is that the time used by humans will be more efficient and reduce measurement errors (FITRIYANTI, 2017). This tool uses a weight sensor (load cell) to measure weight and an ultrasonic sensor to measure height, combined with Arduino, where the measured height and weight can be seen directly through the LCD screen and speakers (Ludya, Herlambang, & Yunidar, 2023).

Efforts to make weight and height-measuring devices have been carried out by several researchers, including Fadli (RIDHO, 2016), who designed and built an ideal weight and height-measuring device based on a microcontroller. (EKO PRAYOGA, 2017) also developed a weight and height measuring system that uses a microcontroller AT89S51. Furthermore, there is research on developing integrated digital height and weight-measuring instruments (Iswandy & Suhemi, 2017). Dila Taufik has also made the weight and height measurement system display sound output and LCD. Therefore, in the design of this tool, a height and weight measuring instrument was developed whose measurement results included ideal, fat, and thin information, which is presented in the form of writing on the LCD and in the form of sound on the speaker (NIRWANTO, n.d.). Thus, height and weight measurements become more accessible, faster, practical, accurate, and complete with ideal weight information (Cahyono & Suprayitno, 2018).

The purpose of this study is to provide an instrument that can be used to measure height and weight and whether or not a person's body is ideal.

Research Methods

The design of this tool consists of several main parts, namely the Microcontroller and ultrasonic sensor HC-SR04, a 180 kg load cell, and a push-button as input to the microcontroller. The ultrasonic sensor acts as a height reader, the load cell acts as a weight reader, and the push button acts as an input for the user's gender choice as input to the microcontroller, which will be processed and produce number output through the LCD and the form of sound through the speaker. Voice data is first recorded and then stored in an SD Card in WAV format. For the microcontroller to access data on the SD Card, an SD Card module must be used to communicate with the microcontroller.

Electronica/Hardware Planning

In hardware design, from push buttons, ultrasonic sensors, and load cells to LCD performers and sound output through speakers that output results from height and weight measurements.

Ultrasonic Sensor Family (HC-SR04)

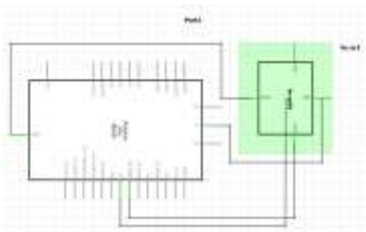

Figure 1. Design of Ultrasonic Sensor to Microcontroller

The tests in this section relate to the accuracy of the ultrasonic sensor HCSR-04 in measuring distances according to the design in Figure 23. The circuit from the ultrasonic sensor (HC-SR04) to the microcontroller (Arduino UNO) is as follows: VCC pin connected to pin 5V, GND to GND, trigger pin to pin 6, and echo pin to pin 7. This test is done by comparing the actual height with the high reading on the sensor.

Heavy Sensor Network (Load Cell)

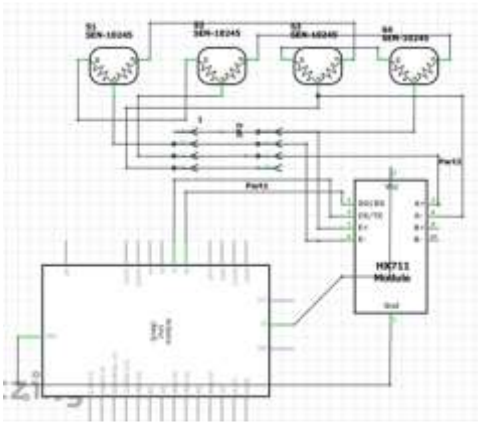

Figure 2. Load Cell to Microcontroller Family

This test relates to the accuracy of the load cell in weighing with the design in Figure 24. The load cell circuit to the microcontroller is connected to the Hx711 module with the following pins: the white wire on the upper left load cell is connected to the white wire of the upper suitable load cell, the white wire of the lower left load cell is connected to the white wire of the lower suitable load cell, the black wire of the upper left load cell is connected to the black wire of the lower left load cell, The black wire of the upper suitable load cell is connected to the bottom left black wire, the red wire in the load cell is connected to the Hx711 module with the following pins: the red wire of the lower suitable load cell is connected to E+, the red wire of the upper left load cell is connected to E-, the red wire of the upper suitable load cell is connected to A-, the red wire of the lower left load cell is connected to A+. It is also connected to Arduino UNO with pins VCC to 5V, GND to GND, DT to pin A0, and SCK to pin A1. This test is done by comparing the actual body weight with the weight reading on the sensor.

Push Button Network

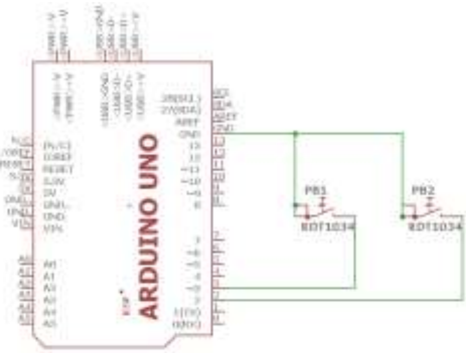

Figure 3. Push the Button to the Microcontroller circuit

The push button is first pressed to start measuring the HC-SR04 ultrasonic sensor and load cell weight sensor. Push button1 (PB1) is used to read female criteria, and push button2 (PB2) is used to read male criteria. A series of push buttons are connected to the microcontroller by pins: PB1 foot to pin 6, PB2 foot to pin 7, and the other leg to GND.

LCD Network

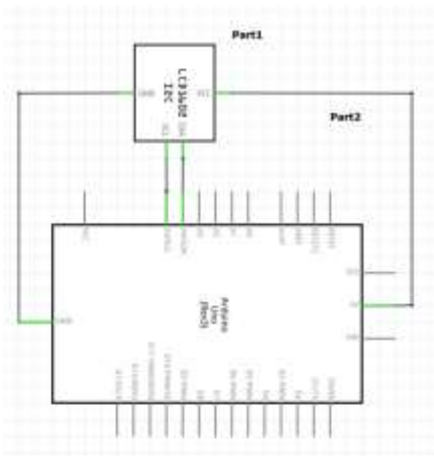

Figure 4. LCD to Microcontroller Family

The LCD serves as a user's high appearance and weight and features ideal criteria, such as fat and thin. The LCD is assisted by the I2C module so that the pins inserted into the microcontroller are slightly more compared to the LCD legs. Up to the LCD I2C network to the microcontroller with the pin: VCC to 5V pin, GND to GND, SDA to SDA pin, and SCL to SCL pin.

Speaker Network

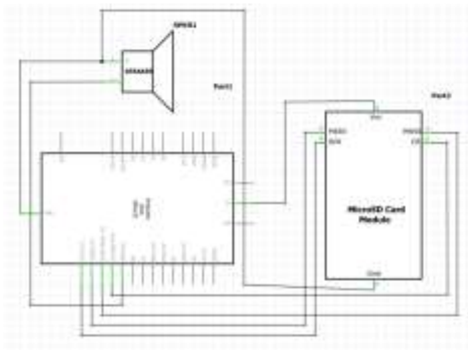

Figure 5. Speaker to Microcontroller Circuit Using Modul SD Card

The speaker serves as an output to emit the user's high voice, weight, and ideal criteria, fat and thin. Connect the speaker to the microcontroller assisted with the SD card module as the place or position of the SD Card/memory. The speaker-to-microcontroller network uses the SD Card module with a VCC pin to pin 9 and GND to GND (speaker). VCC to pin 5V, GND to GND, CS to pin 10, SCK to pin 13, MOSI to pin 11, and MISO to pin 12.

Software Planning

The design of this software consists of flowcharts. A flowchart of a digital gauge for height and weight with microcontroller-based sound output can be seen in Figure 6 and Figure 7 below.

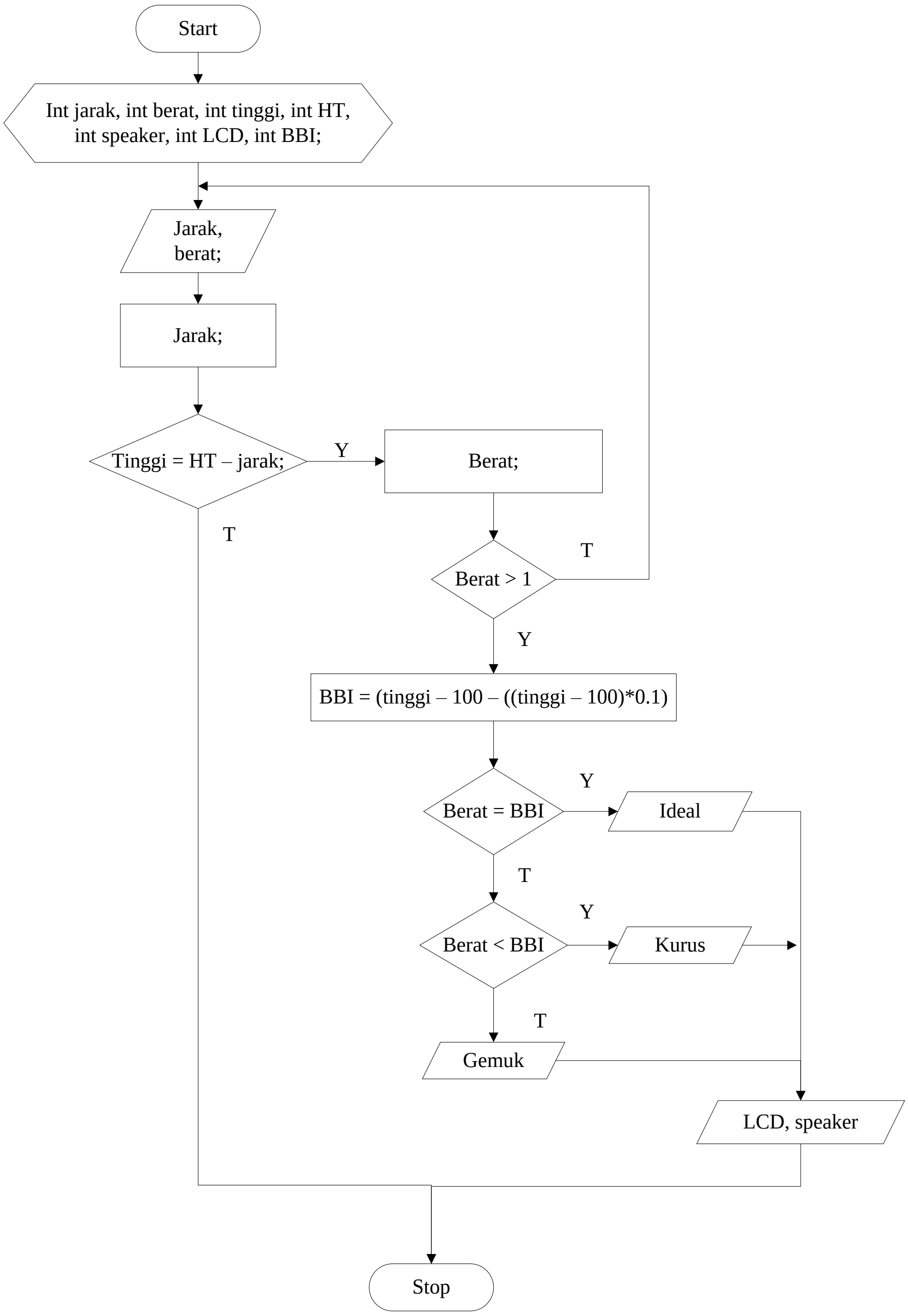

Figure 6. Flowchart of Male Height and Weight Measuring Instruments

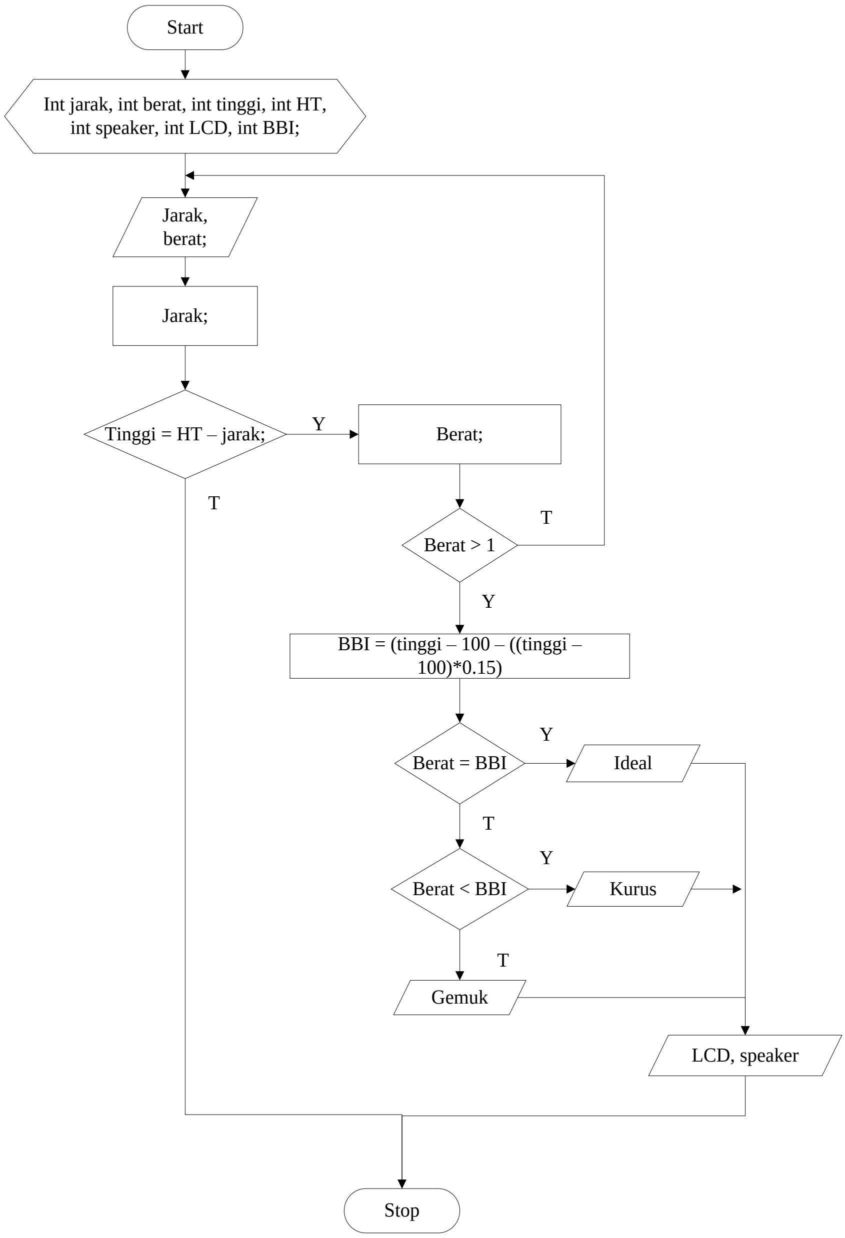

Figure 7. Flowchart of Women's Height and Weight Measurement Tool

Mechanical Planning

This section will show the entire construction drawing of the 2D design tool drawn by the author in Figure 8.

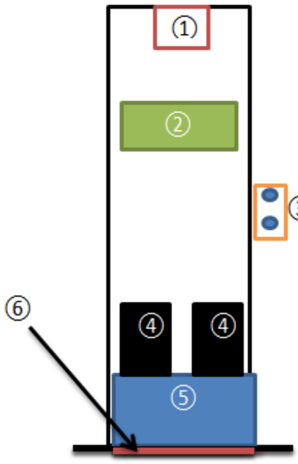

Figure 8. 2D Design

Tool section description:
1. Ultrasonic sensor placement
2. Area LCD
3. Placement of push button
4. Active speaker placement
5. Microcontroller placement box, SD card module and SD card, and Power Supply
6. Load Cell sensor placement

From software planning, hardware planning, and mechanical planning above, height and weight measurements determine the ideal weight using the Broca hokum. Broca's hokum formula:

Woman: BBI = (TB – 100 – ((TB – 100)*15%))
Man: BBI = (TB – 100 – ((TB – 100)*10%))

Information: BBI = ideal weight (kg)
TB = height (cm)

Broca's formula: Broca's formula cannot be used to diagnose diseases or health problems in a person. Broca's formula is just one simple and easy way to estimate a person's ideal weight based on height. Calculating the ideal body weight with Broca's formula is only sometimes accurate because age and bone weight factors or body proportions exist.

Results and Discussion

Height System Testing

Height system testing is carried out by comparing height measurements using design tools against conventional height measurements using a meter. Determining the error percentage of height can be calculated by the following formula:

$$\text{Error} = \frac{Real\ hight - Measurable\ hight}{real\ hight}\ x\ 100\%$$

The test results are shown in Table 1. The following

Table 1
Height measurement test results (TB)

No	Name	TB Actually (cm)	TB Terukur (cm)	Error Percentage (%)
1.	Refan	185	185	0
2.	Rivaldo	171	172	0.58
3.	Feni	152	151	0.66
4.	Arga	164	164	0
5.	Asep	172	173	0.58
6.	Kelana	178	178	0
7.	Hanni	151	152	1.33
8.	Zaida	152	153	0.65
9.	Ji'i	150	152	0.67
10	Deta	171	171	0
Average error percentage difference				0.45

From Table 2. The results of conventional height and height measurements are obtained from the results of the tools that have been designed so that the percentage error results are obtained, with the following search: measured height 151 cm, actual height 152 cm.

Persentase error = $\frac{Real\ hight - Measurable\ hight}{Real\ hight}\ x\ 100\%$

$= \frac{152\ cm - 151\ cm}{152\ cm}\ x\ 100\%$

$= 0.66\%$

So, the average error rate in height measurement with 10 different users is 0.45%.

Weight Loss System Testing

The weight system testing is carried out by comparing the measurement results using a design tool against the results of weight measurement using a conventional digital scale. Determining the percentage of error in body weight can be calculated by the following formula:

Error = $\frac{Really\ heavy - Measured\ weight}{Really\ heavy}\ x\ 100\%$

Both weight measurement results are shown in Table 2. the following.

Table 2
Weight measurement (BB) test results

No	Name	BB Actually (kg)	Rated BB (kg)	Error Percentage (%)
1.	Refan	83	81	2.41
2.	Rivaldo	65	65	0
3.	Feni	40	41	2.5
4.	Arga	46	46	0
5.	Asep	48	47	2.08
6.	Kelana	69	70	1.44
7.	Hanni	53	51	3.77
8.	Zaida	50	50	0
9.	Ji'i	45	44	2.22
10.	Deta	61	62	1.64

Average error percentage difference	1.60

From Table 3. The results of conventional weight measurement and body weight are obtained from the results of the designed tool so that the percentage error results are obtained, with the following search: measured weight 81 kg, actual weight 83 kg.

Error = $\frac{Really\ heavy - Measured\ weight}{Really\ heavy}\ x\ 100\%$

$= \frac{83\ kg - 81\ kg}{83\ kg}\ x\ 100\%$

= 2.41%

So, the average error rate in weight measurement with 10 different users is 1.60%.

Criteria Viewer System Testing

The testing of the ideal body, thin, and fat criteria viewer system was calculated using Broca's formula. The formula for calculating the ideal body weight (BBI), according to Broca, is as follows:

Women: BBI = (TB – 100 – ((TB – 100)*15%))

Man: BBI = (TB – 100 – ((TB – 100)*10%))

The results of a person's body criteria are obtained with Broca's formula in Table 3.

Table 3
Criterion viewer system testing

No	Name	TB Terukur (cm)	Rated BB (kg)	BBI (kg)	Criterion
1.	Refan	185	81	77	Fat
2.	Rivaldo	172	65	65	Ideal
3.	Feni	151	41	43	That
4.	Arga	164	46	58	That
5.	Asep	173	47	66	That
6.	Kelana	178	70	71	That
7.	Hanni	152	51	44	Fat
8.	Zaida	153	50	43	Fat
9.	Ji'i	152	44	44	Ideal
10.	Deta	171	62	61	Fat

From Table 4. A user's ideal body criteria (BBI) are obtained by calculating using the Broca formula. So the BBI value is obtained as follows: TB (L) 185 cm, BB (L) 81 kg, TB (P) 151 cm, BB (P) 41 kg.

Woman: BBI = (TB – 100 – ((TB – 100)*15%)) = (151 – 100 – ((151 – 100)*15%))

= 51 – 7.65

= 43.35 kg

From these results, the ideal body weight of 43.35 kg was obtained, while the weight of the tool that had been designed was 41 kg, so the body criteria were declared thin.

Man: BBI = (TB – 100 – ((TB – 100)*10%))

= (185 – 100 – ((185 – 100)*10%)) = 85 – 8.5
= 76.5 kg

From these results, the ideal body weight of 76.5 kg was obtained, while the weight of the tool that had been designed was 81 kg, so the body criteria were declared fat.

Sound Viewer System Testing

The sound viewer system consists of an Arduino (as a controller), an SD card module, and speakers. This system works to produce sound information according to body weight conditions. Previously, the sound was first recorded and stored on the SD card. This sound viewer system test is intended to test the system's performance in displaying sound precisely according to the user's weight condition. The data for these test results are shown in Table 5.

Table 4
Sound viewer system testing

Name	TB Terukur (cm)	Rated BB (kg)	Criterion	Voice output
Refan	185	81	Fat	Your body height is a hundred and eighty-five, your weight is dy-one, and your body criteria are fat.
Rivaldo	172	65	Ideal	Your body height is one hundred and seventy-two, your weight is six pulu five, and your body criteria are ideal.
Feni	151	41	That	Your body height is fifty-one, your weight is forty-one, and your body criteria are thin.
Arga	164	46	That	Your body height is a twenty-four-name; your weight is forty-six criteria, and your body is thin.
Asep	173	47	That	Your body height is a hundred and seventy-three, and your weight is forty-seven. Your body criteria are thin.

Kelana	178	70	That	Your body height is one hundred and seventy-eight, your weight is seventy, and your body criteria are thin.
Hanni	152	51	Fat	Your height is one hundred and fifty-two, your weight is fifty-one, and your body is fat.
Zaida	153	50	Fat	Your body height is one hundred and fifty-three, your weight is fifty, and your body criteria are fat.
Ji'i	152	44	Ideal	Your body height is fifty-two, your weight is forty-four, and your body criteria are ideal.
Deta	171	62	Fat	Your body height is seventy-one, your body is sixty-two, and your body is fat.

LCD Display

The display of the LCD screen during the height and weight measuring instrument can be seen as follows:

Figure 9. Initial Display on LCD

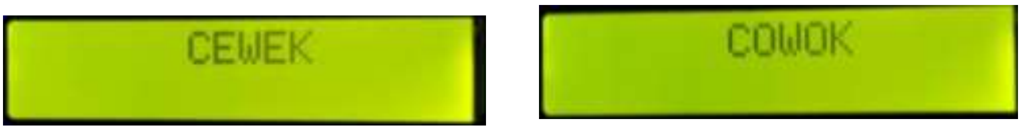

Figure 10. Display Push Button Options

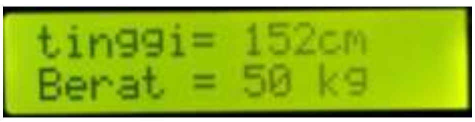

Figure 11. LCD Screen Display at the time of Measurement

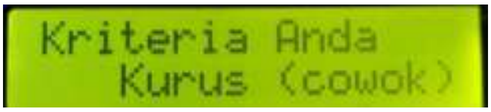

Figure 12. Display of Body Criteria

Conclusion

Based on the design and results of system testing that has been carried out, it can be concluded that: (1) Height measurement with 10 different users has an error rate of 0.45%. (2) Weight measurement with 10 different users has an error rate of 1.60%. (3) From 10 users, there are criteria with a ratio of 1:2:2 (ideal:fat: thin). (4) The sensors have measured the appearance of sounds for height, weight, and criteria. (5) The LCD is as desired.

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