Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 6, Number 3, July 2022
DOI : https://doi.org/10.33395/sinkron.v7i3.11580
e-ISSN : 2541-2019
p-ISSN : 2541-044X

The prototype of IOT based weight scale and calorie tracking application

Dita Ayu Chairunnisa[1)]*; Ahmad Taqwa[2)]; Irma Salamah[3)]
[1)2)3)]State Polytechnic of Sriwijaya, Palembang, Indonesia
[1)]ditaayuch18@gmail.com, [2)]taqwa@polsri.ac.id, [3)]irma.salamah@yahoo.com

Submitted : July 25, 2022 | **Accepted** : July 25, 2022 | **Published** : July 28, 2022

Abstract: Pandemic has affected the level of intensity in public activities. This has changed the state of human health as well as pattern in social life. This research designs the prototype of IoT-based scale with calorie tracking application in purpose to help optimize the application of healthy lifestyle. This research which uses waterfall method is done through numerous steps including analysis of needs, designing the devices and system, software programming, device integration, device testing, and maintenance. This research developed IoT-based scale with sensor load cell and HX711 module as weight sensor component, Node MCU as microcontroller component, battery as voltage source, and firebase as database to store the result of body weight measurement. Android application developed with Android Studio, visual studio code, and java programming language. IoT-based scale is functioned to measure body weight in real-time which connected to android application to display body weight, calculate Body Mass Index (BMI), calculate daily calories needs including Basal Metabolic Rate (BMR) and Total Energy Expenditure (TEE), provide information of food calories and exercise and total calories recording to monitor daily intake and output. As results, IoT scale and android application worked according to the designed system. IoT scale can measured body weight and send the measurement result to the application. The application successfully received the weight data from IoT scale, giving information regarding calories need, calories intake, and exercise to help the user applies healthier lifestyle.

Keywords: Android, Calories, Internet of Things (IoT), Load Cell, NodeMCU

INTRODUCTION

COVID-19 pandemic hugely affects the way people live these days. Activity restriction regulations such as work from home, physical distancing, and lockdown, decrease the intensity of human physical activities. The decrease of physical activities intensity marked by the increase of sedentary behaviour such as sitting or lying down, playing gadget, and watching television. Such behaviour result in low energy output which increase the risk of non-communicable disease (Fadhel Nurmidin et al., 2020).

The impact could be prevented through healthy lifestyle, giving a positive change on dietary habit, sleep quality, and stress level on someone. Healthy lifestyle should be done based on someone's own will, without any external pressure, so that it could be done well. Healthy lifestyle could e started from daily habit such as maintaining good hygiene, consuming healthy and nutritious food, balanced physical activities, and regular exercise (Asri et al., 2021).

Internet of Things has applied on various scientific fields, such as economy, social, transportation, industry, and health. This is because Internet of Things is a wireless technology that could connect between hardware and cellular network or internet which is closely related to daily life. Application of Internet of Things let the system to work real-time, also give the ability to communicate and provide a good security (Tjipto & Dewantoro, 2022).

Directorate General of Informatics Application under Ministry of Communication and Informatics (KOMINFO) Republic of Indonesia stated that cellular technology user, specifically internet, increase 11 percent with total users of 202,6 million in 2021 (Direktorat Jenderal Aplikasi Informatika, n.d.). Increasing percentage of internet user is the result of rapid development of cellular technology, including development of android-based application which accommodates daily life (Antoni & Suharjana, 2019).

Based on research done by Rahadian Bisma, et al. in 2021, the development of application which could give information of daily calories need based on calculation of energy expenditure and also record the amount of

*name of corresponding author

calories fulfilled has been done (Bisma et al., 2021). Research done by Levi Ali Syahbani et al., in 2021 has developed healthy lifestyle management application which could give information regarding calories need, food nutrition information, and exercise that should be done daily (Syahbani et al., 2021).

In this research, application has been developed with the updated feature from the previous research, which adds information of body mass index (BMI) to determine body condition based on body weight; giving calculation of daily calories need not only from the calculation of energy expenditure, but also considering basal metabolic rate (BMR); giving information of food calories and exercise; and creating an Internet of Things based scale which could give real-time information of actual body weight to help calculate the calories need.

Based on description above, the main goal of this research is to create system which could help the community to apply healthy lifestyle to decrease risk of non-communicable disease by creating Internet of Things based scale paired with calories recorder application.

LITERATURE REVIEW

Internet of Things is a technological development used to transfer data over a network using sensors or electronic components connected to the internet(Wilianto & Kurniawan, 2018). Loadcell sensor is a transducer components which detect and convert load values into a measurable electrical output in weight scale (Jamaludin, 2018). HX711 module is an amplifier used to amplifies and send voltage signal from loadcell to microcontroller board (Fauzi et al., 2019). Node MCU is a microcontroller with internet access ability which receive measured data from sensor load cell and sending it to firebase as database (Satriadi et al., 2019).

Firebase is a cloud service with back-end system used for web and mobile application development (Sonita & Fardianitama, 2018). Firebase is real time database platform. If there is a data change, the application connected to firebase will update directly through every device, either website or mobile.

Android is Linux-based mobile devices operating system. It is included operating system, middleware, and application. Android is a comprehensive opensource platform designed for mobile devices. Android can be developed through an IDE software called android studio (Silvia et al., 2014). Java is a programming language used to develop mobile applications. is a scripting programming language in mobile application development (Fikri Sallaby et al., 2015).

Body Mass Index (BMI) is the anthropometric to define height and weight characteristics either classifying (categorizing) them into groups in adults (Nuttall, 2015). Generally, this measurement is used to represent an individual fat index. BMI formula is declared below:

$$\text{BMI} = \frac{\text{Body Weight (kg)}}{(\text{Body Height})^2\ (\text{m}^2)} \quad (1)$$

Basal Metabolic Rate (BMR) is the minimum calorie or energy required to maintain normal physiological function at rest. BMR calculations differ between male and female (Tamsir & Hozeng, 2016). The formula of BMR as declared below:
BMR for Male:

$$\text{BMR} = 66 + (13{,}7 \times \text{Weight}) + (5 \times \text{Height}) - (6{,}8 \times \text{Age}) \quad (2)$$

BMR for Female:

$$\text{BMR} = 65{,}5 + (9{,}6 \times \text{Weight}) + (1{,}8 \times \text{Height}) - (6{,}8 \times \text{Age}) \quad (3)$$

Total Energy Expenditure (TEE) is the total energy or maximum calorie needed in optimal used body or during activities. The value of TEE calculate by 60-80% basal metabolic rate, 10% food's intake energy, and about 15-30% burned calories from workout (Putra Utama et al., 2019). Based on those definition, TEE formulation is declared below:

$$\text{TEE} = \text{BMR} \times \text{Weekly Workout Intensity} \quad (4)$$

METHOD

The research method is waterfall method. Waterfall method called as linear sequential model is a systematic and sequential software development model. This method developed in steps of research requirement analysis, design, modelling, implementation. This method supports a complete software development system(Wahid, 2020). The waterfall method which is linear system makes the steps must be done sequentially from beginning to end. The next step can be done after one step is completed. This method often causes difficulties due to the

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potential for errors in the previous process so large that it must be redeveloped. However, the waterfall method can produce a good and detailed research(Akbar & Gunawan, 2020).

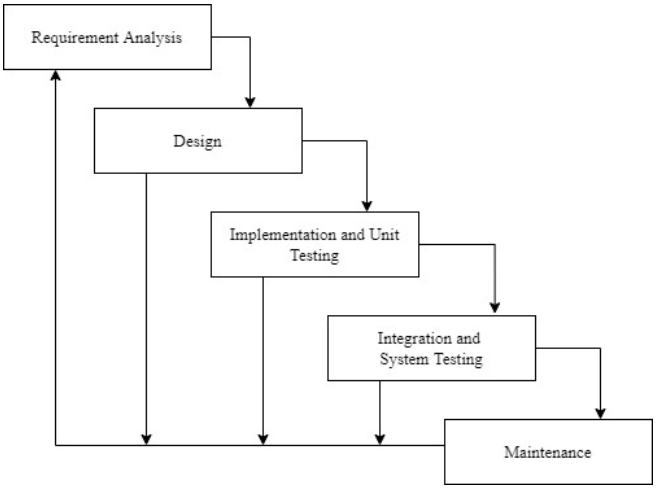

Fig. 1 Waterfall Method

Waterfall method applied in several steps which are requirement analysis, design, implementation, integration and system testing, ended with maintenance. First step is requirement analysis. This step helps perform the needs of tools and program development by giving out the components data information. The second step is designing the product development. This step determines the design and the working procedure of both hardware and software. The third step is implementation and unit testing. Implementation is identical to the software programming process.

This study made an android application programmed with android studio and visual studio in java code. Unit testing is a step to test the functionality of each device. The functionality of the IoT based scale is tested by measuring the weight on the scale and compare it with weight measurements on general scales. Comparison of measurement results is carried out to test the level of accuracy of the scales. The fourth step is integration and system testing. This step determines the integration process between the IoT based scale and android application. Integration process shows the application of the Internet of Things fundamental. System testing is the process to see the integrated devices and system are working. The last step is maintenance. This step determines the process of products maintenance.

RESULT

Requirement analysis process has provided the information about electronic components for hardware development and the supporting software for android application development. The electronic components that will be used are load cell sensors, HX711 modules, batteries, and NodeMCU. Supporting software that will be used in developing android applications are android studio and visual studio code with the java programming language.

The design step determines the flow of the devices working system in an activity diagram. Waterfall method helps to implement the working system so that the android application works according to a predetermined flow. It starts from creating user account and continued with logging into the account. The android application decides the next step according to the calorie needs value saved in the account. If it’s detected at null or no data, the application will take the user to calories calculation page. At this page, user needs fill their height, weekly workout intension, and measure the body weight using the IoT based scale. The calculation provides the value of BMI, BMR, and TEE shown in Profile Page. In the android application, user can monitor their daily calorie needs through food consumption and workout.

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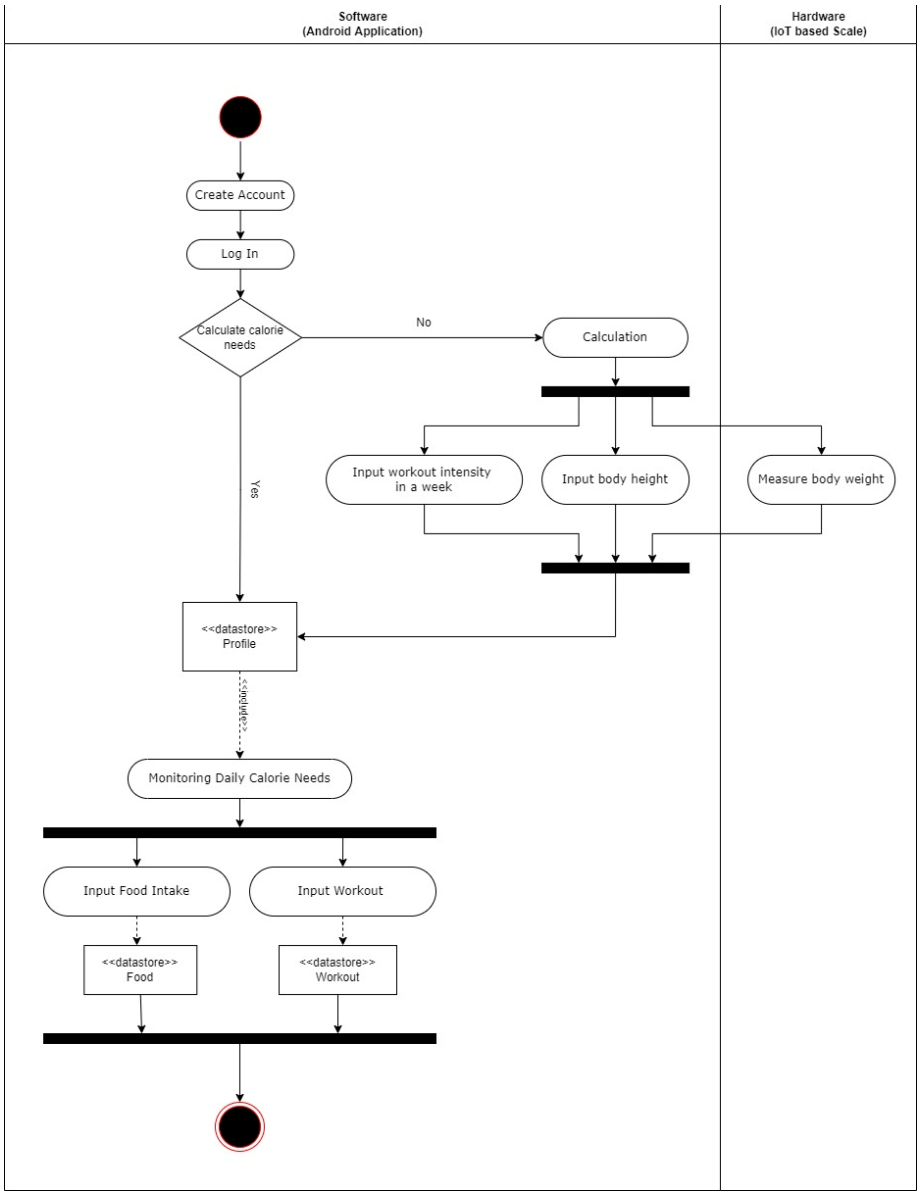

Fig. 2 Working System Activity Diagram

On the hardware design, sensor load cell functioned to detect resistance received by the sensor caused by load. Resistance will be delivered to HX711 module. HX711 module amplifies the signal that will be sent from sensor load cell to Node MCU. Node MCU is a microcontroller with internet access ability which receive measured data from sensor load cell and sending it to firebase as database. The data will be continuously sent and shown on android application.

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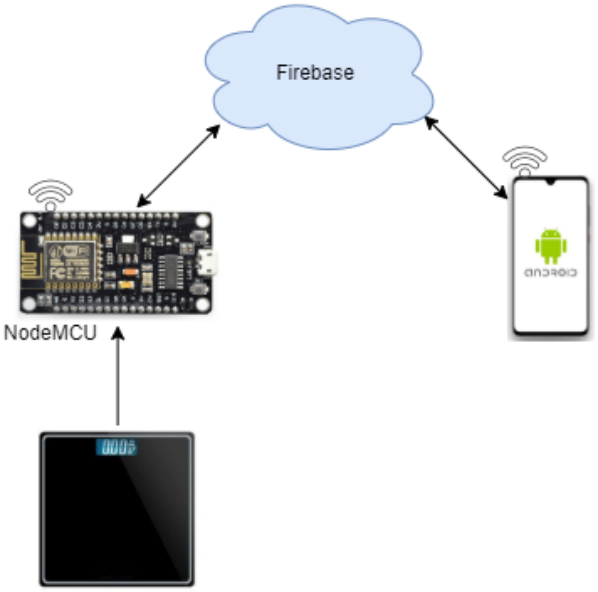
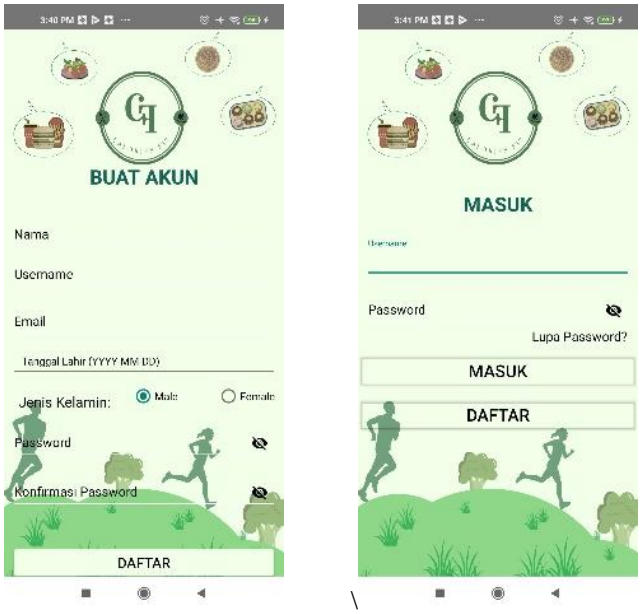


Fig. 3 IoT based Scale Communication Scheme

The use of x starts with creating account by inputting user data such as name, username, email, birth date, gender, and password. This account will used to save user profile, calorie needs calculation, and calorie monitoring. User cannot use the application without account. After creating account, user need to logged the account in.



(a) (b)

Figure 4. (a) Sign Up Page, and (b) Log In Page.

Android application gives the calculation of Body Mass Index (BMI), Basal Metabolic Rate (BMR), and Total Energy Expenditure (TEE). User need to input their body weight, height, and workout intensity in a week. These input values have been customized based on BMI, BMR, and TEE formulas. The calories calculation results is shown in Profile along with BMI, BMR, and TEE values. User can recalculate their daily calories needs so they can get the right needs values real-time.

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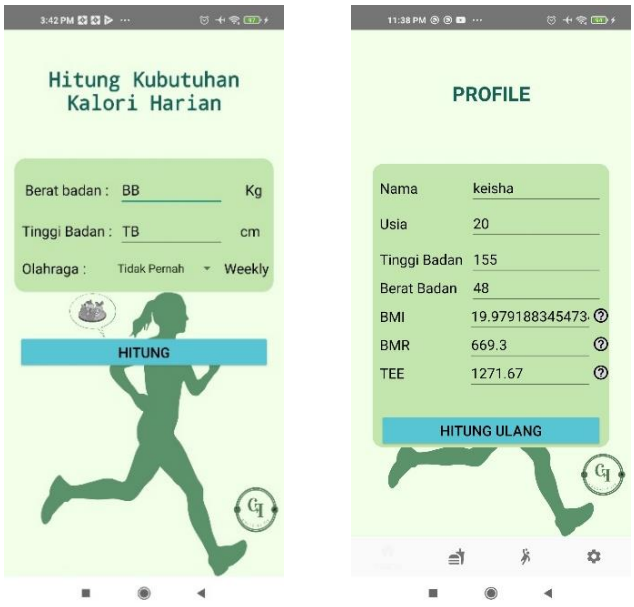
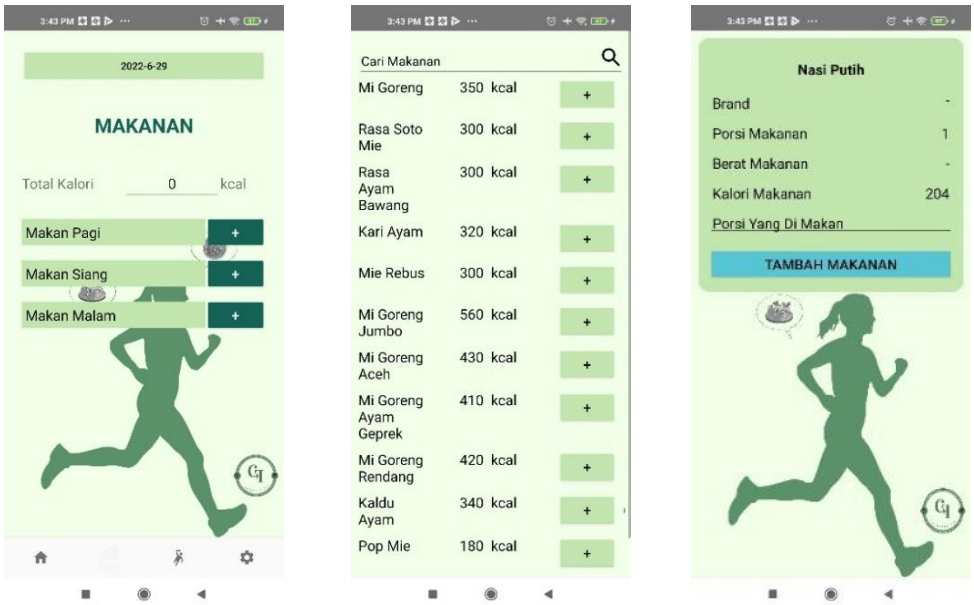


(a) (b)

Fig 5. (a) Calorie Calculation Page, and (b) Profile Page.

Android application could monitor the amount of calories intake based on food data input on application. The process starts from the user choosing the consumed food type based on choices provided by application database, either they can find the name of food in the food searching page. It continued by inputting the portion of food consumed. Food calories count resulted from multiplication of portion consumed to food calories. Calories total shown in Food page are from calculation of food calories intake.



(a) (b) (c)

Fig. 6(a) Food Page, (b) Food Searching Page, and (c) consumed food amount input page.

Android application also monitor the burned calories through workout. It proceed user's selected workout, value of workout that has been done, by saving and noted the total calories at the top of workout page.

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Fig.7 Workout Page

After the implementation of device successfully done, testing will be done to determine whether the scale is functioning properly and able to send the body weight data to the android application, also to determine the accuracy rate of body weight measurement. Body weight measurement testing are done on 15 Electrical Engineering undergraduate students in State Polytechnic of Sriwijaya by comparing body weight measured on two different scales, which is IoT and digital scale. Testing result of the scales are shown on Table 1.

Table 1. Body Weight Measurement

No.	Student Name	Digital Scale Measurement	IoT Based Scale Measurement	Measurement Error
1.	Redho	63,9	62,96	0,94
2.	Sakinah	59,5	58,46	1,04
3.	Ika	49,4	48,87	0,53
4.	Widia	48	47,18	0,82
5.	Felia	48	46,98	1,02
6.	Naura	54,4	53,28	1,12
7.	Rani	60,25	58,79	1,46
8.	Selvi	50,75	50,19	0,56
9.	Ririn	66,55	65,38	1,17
10.	Ira	42,8	41,77	1,03
11.	Yuda	65,7	64,4	1,3
12.	Fandhepa	48,5	47,71	0,79
13.	Edo	61,2	60,55	0,65
14.	Salwa	51,1	50,48	0,62
15.	Jatiko	60,6	59,67	0,93
	Total	**830,65**	**816,67**	**13,98**

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Table 1 shows the result of testing result between IoT based scales and general scale. According to the testing result, the accuracy of weight measurement can be calculated as follows:

Error = Digital scale measurement – IoT based scale measurement (5)
ΣError = 13,98

$$\text{Error Percentage} = \frac{\Sigma|\text{Error}|}{\Sigma(\text{IoT based scale measurement})} \text{x } 100 \quad (6)$$

$$\text{Error Percentage} = \frac{|13,98|}{830,65} \text{x } 100 = 1,68\%$$

Accuracy = 100 – (Error Percentage) (7s)
Accuracy = 100 – 1,68 = 98,32 %
Thus, the level of accuracy of weight measurement by IoT based scales is 98,32%.

DISCUSSIONS

The testing of work system is the step to knows whether the hardware and software have been successfully integrated. This test determines IoT based scale is successfully connected to the system and measured the body weight which displayed on the android application. The testing is also used to see the works of android application features. This application testing uses black box testing in terms to check on the functionality. The results of this testing shown on the table below:

Table 2. Application Black Box Testing Result

No	Testing Menu	Tested Function	Input	Output	Testing Result
1.	Sign Up	Creating account	Click sign up button on log in page	Data saved to database and app directly move to log in page	Match
2.	Log In	Log Into User's Account	Typing the correct email and password	Logged into system and goes to profile page	Match
			Typing the correct email and password	Stay in log in page	Match
3.	Profile Menu	Showing user's data	Click profile menu on navigation button	User's data appeared	Match
		Calculate BMI, BMR, and TEE	Click "hitung" button	BMI, BMR, TEE value appeared on profile menu	Match
4.	Food Menu	Food consumption monitoring	Food name and portion by clicking "+" button	Food calories	Match
5.	Workout Menu	Workout monitoring	Workout name by clicking "+" button	Workout calories	Match
6.	Setting Menu	Change password	Current password and new password. Then, Click change password button	Password changed and directly moved to log in page	Match
		Log Out	Click log out button	Move to log in page	Match

Testing result of android application features successfully work without any problem. Application could show body weight measurement result, calculating daily calories need, and recording calories intake and output that shown below:

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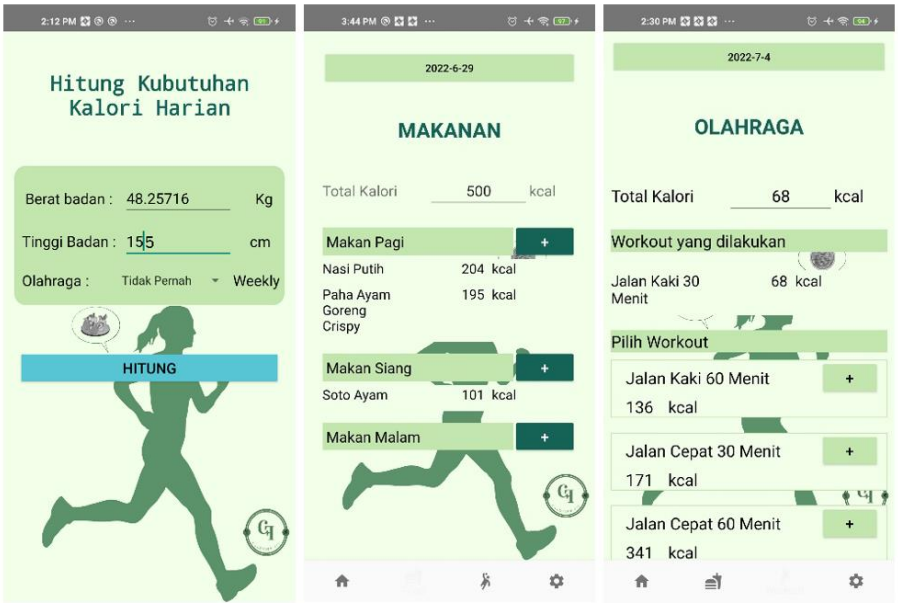

Figure 8. Android Application Testing Results.

CONCLUSIONS

IoT scale and android application worked according to the designed system. IoT scale testing result shows body weight measurement result with accuracy rate 98,32%. The application successfully shows body weight measured by IoT scale, giving information regarding calories need, calories intake, and exercise to help the application healthy lifestyle.

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