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Android-Based Lifestyle Management Application for Type-2 Diabetes Mellitus Patients

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ABSTRACT: Diabetes Mellitus (DM) Type-2 is a chronic disease that occurs due to uncontrolled blood glucose levels in the body. Uncontrolled glucose levels in people with Type-2 Diabetes Mellitus can cause various kinds of complications, therefore this research aims to create an Android application that can help people with Type-2 Diabetes Mellitus in controlling blood glucose levels. This application creation method includes the stages of preparation and application creation by conducting previous literature studies, which produce a theoretical model. The result of this research is a lifestyle management application for type 2 diabetes mellitus patients called Selfcare Glucose Management (SCGM), which has 4 kinds of features, including a feature that can calculate daily calorie needs by displaying various types of food with a predetermined weight and number of calories, an alarm feature that functions to remind patients to take medication and inject insulin, a physical activity training feature and a feature that contains educational material about Diabetes Mellitus. This application has been tested using application measurement methods in the form of repeated manual calculations or calibration and obtained results that match the expected values. It is hoped that this application can be developed to be more interactive and communicative in its use.

KEYWORDS: Application; Android; Diabetes Mellitus; Blood Glucose; Selfcare Glucose Management

I. INTRODUCTION

From the perspective of genetic and clinical studies, diabetes is a metabolic disorder in the human body that recurs as a loss of the body's tolerance for carbohydrates. If it develops clinically, diabetes is characterized by fasting and postprandial hyperglycemia, atherosclerosis, and microangiopathic vascular disease [1]. Type 2 diabetes is a disorder of the body's metabolic system that is characterized by high blood sugar levels due to decreased insulin secretion by pancreatic beta cells also known as insulin action [2].

Diabetes causes many complications such as heart disease, stroke, neuropathy, and kidney failure, and can even lead to amputation if there is gangrene anywhere on the body.[2]. Diabetes can cause various losses, including the impact on the social environment and the impact on the sufferer's finances. Diabetes can also cause losses which are classified as direct and indirect losses. Direct losses include the costs of treatment, hospitalization, various medical services, outpatient treatment, laboratory tests, operations, regularly consumed medicines, and various other equipment

The results of a health survey conducted in 2017 showed that the number of diabetes sufferers in Asia had increased to 57 percent. Type-2 diabetes occurs more often in women than men. Women have a higher risk of developing diabetes because physically women have a higher body mass index. Global Diabetes data has reached up to 371,000,000 people, with type 2 diabetes accounting for 95% of the world's population with diabetes and only 5% remaining with type 1 diabetes mellitus, and keeps increasing every year [3][4].

Insulin resistance has recently become a concern because of its association with type 2 diabetes, so we can take steps to prevent insulin resistance by preventing hypertension, obesity, and dyslipidemia, which essentially starts with insulin resistance, which predicts cardiovascular disease and type-2 DM[5].

There are several ways to prevent type 2 diabetes, one of which is by identifying risk factors for its development. Type-2 Diabetes Mellitus has 2 risk factors, namely modifiable and non-modifiable risk factors. The factors in question can be modified, such as lifestyle by consuming food that meets calorie needs, stress management, regular rest patterns, and physical activity. The factors in question that cannot be modified are genetic factors and age factors [6].

The number of calories that can be consumed by type 2 DM sufferers must be following the energy needed for daily activities. Everyone's energy needs are not the same, they vary depending on several determining factors, such as gender, age, physical activity, and body condition. In determining the required calorie requirements, the number

of kcal /day is calculated from the health sector's calorie intake to estimate daily calorie needs.[7].

Based on this explanation, this research was conducted to develop an Android-based lifestyle control application for type-2 Diabetes Mellitus patients. This application aims for self-care for diabetes mellitus sufferers to prevent an increase in blood glucose levels.

II. RESEARCH METHODOLOGY

A. Type-2 Diabetes Mellitus

Diabetes Mellitus is a degenerative disease that is increasing in prevalence in the world and most of it is type 2 diabetes mellitus. The increase in Diabetes Mellitus cases occurred due to changes in people's diet and lifestyle.[8].

In people with type 2 diabetes, insulin sensitivity to glucose levels is reduced and this can cause the liver to continue producing glucose even when glucose levels reach high levels. Beta cells exposed to hyperglycemia become less efficient in responding to increased glucose. This event is called desensitization and can lead to normalization of glucose levels. Another pathophysiological process in type 2 Diabetes Mellitus is the activity of biological insulin resistance both in peripheral tissues and in the liver. This condition is called insulin resistance [9].

Most of the risk factors for diabetes are lifestyle changes, which include low physical activity, unhealthy and unbalanced diet, excess body weight, hypertension, hypercholesterolemia, and alcohol and tobacco consumption. Therefore, diabetes treatment is focused on controlling risk factors through integrated and holistic preventive and promotive aspects. Low-carb diets and the use of diabetes medications are considered the best ways to manage type 2 diabetes mellitus [10],.

Type 2 Diabetes Mellitus occurs due to relative failure of beta cells and insulin resistance, namely the reduced ability of insulin to take up glucose from peripheral tissues and suppress hepatic glucose. Beta cells cannot fully compensate for insulin resistance, which means a relative lack of insulin. The incidence of decreased insulin release upon glucose stimulation and associated with other insulin-stimulating agents, results in increased sensitivity of pancreatic beta cells to glucose.

World Health Organization (WHO). (2016), explains that there are six risk factors associated with Type 2 Diabetes Mellitus,[11], [12], including:

1. Obesity

There is a significant relationship between obesity and blood sugar.At the level of obesity with a BMI > 23 which can cause blood glucose levels to reach 200 mg .

2. Hypertension

An increase in blood pressure above normal levels in hypertensive patients is closely related to inappropriate salt and water retention or increased pressure in the body's peripheral vascular circulation.

3. Dyslipidemia

Dyslipidemia is a condition characterized by increased blood fats (triglycerides > 250 mg/dL). There is an association between increased plasma insulin and low High-Density Lipoprotein (HDL) (<35 mg/dL), which is often found in people with diabetes.

4. Age

People over 40 years old are susceptible to Diabetes Mellitus, although those under 40 years old can avoid it. Blood sugar increases around age 45 and the frequency increases with age.

5. Genetic Factors

Type 2 Diabetes Mellitus is thought to be associated with familial aggregation. The empirical risk of developing type 2 diabetes mellitus increases two to six times if a parent or family member suffers from type 2 Diabetes Mellitus.

6. Alcohol and Cigarettes

Individual lifestyles are associated with an increased incidence of type 2 DM. Although much of this increase is related to increased obesity and decreased physical activity, other factors associated with the transition from traditional to Western environments also play a role, including changes in smoking habits and alcohol consumption. Alcohol interferes with blood sugar metabolism, especially in people with type 2 DM, making it difficult to regulate and raise blood sugar.

B. Daily Calories Requirements

Daily calories requirements for humans can be calculated based on several criteria, such as height, weight, gender and age. By knowing a person's height, their ideal body weight can be calculated using the following ideal body weight (IBW) equation.

$$IBW = (Height - 100) - \big((Height - 100) \times 10\%\big) \quad (1)$$

Where IBW value is expressed in kg and height in cm. From the results of IBW calculations, the basal metabolic rate (BMR) can be determined using the following equation.

$$BMR_{male} = 30kkal \times IBW \quad (2)$$

$$BMR_{female} = 25kkal \times IBW \quad (3)$$

Equation 2 amd 3 show the difference between male's BMR and female's BMR. Male's BMR is 30 times of its IBW and for female is 25 times, which is lower than male's BMR. From the results of these calculations, it can be used to determine an individual's daily calorie intake. Based on P2PTM Ministry of Health of the Republic of Indonesia, total daily energy expenditure (TDEE) is the body's calorie needs plus the number of calories when doing physical activity.[13]. TDEE can be calculated with the following equation.

$$TDEE = BMR + (\%activity \times BMR) - (\%correction\ factor \times BMR) \quad (4)$$

According to P2PTM Ministry of Health of the Republic of Indonesia, percent of activity and correction factor are grouped into several categories. Dimana kategori aktivitas dikelompokkan seperti pada table 1.

Table 1. Percentage effect of physical activity

Type of Activity	Activity	%activity (%)
Light Activity	Reading	10
	Driving	10
	Walking	20
Moderate Activity	Sweeping	20
	Fast Walking	30
	Cycling	30
Heavy Activity	Aerobic	40
	Hiking	40
	Jogging	40

The activity groupings in table 1 were selected based on individual average activity for each week. In addition, individual grouping was also carried out to determine the correction factor in the TDEE calculation which is shown in table 2.

Table 2. Correction factor

Age (y.o.)	%correction factor (%)
Under 39	0
40-59	5
60-69	10
70 and above	20

Table 2 shows the correction factors used for TDEE calculations which are based on the metabolic rate of individuals in each age group. Where the human metabolic rate will decrease with increasing age, as shown in table 2, the correction factor will become greater as age increases.
Body mass index will also affect TDEE calculations. In patients with obesity, calorie needs will be reduced by 20% - 30%. Meanwhile, patients with a body weight below IBW will have their calorie requirements increased by 20-30%. The patient's congenital disease condition also determines the level of calorie requirements.

C. Daily Calories Requirements

Diet classification systems based on IBW, BMR, and TDEE can help direct more specific dietary recommendations according to individual needs.[13]. The following is an example of classification based on these factors:

1. Class 1 Diet (normal)

This diet is a diet recommended for individuals with BMI in the normal range (18.5 - 24.9). Calorie requirements (TDEE) are at an appropriate level to maintain a healthy body weight, according to the level of physical activity.

2. Class 2 Diet (to decrease body weight)

This diet is recommended for individuals with an BMI above the normal range (25 and above), indicating overweight or obesity. Caloric intake (TDEE) is reduced to achieve a caloric deficit, to encourage gradual weight loss.

3. Class 3 Diet (to increase Weight)

This diet is recommended for individuals with an BMI below the normal range (below 18.5), indicating underweight. Calorie intake (TDEE) is increased to achieve a calorie surplus, helping with weight gain and recovery.

4. Class 4 Diet (Low Carb/Ketogenic)

This diet is recommended for individuals with high BMI and/or certain health conditions that may benefit from a low-carbohydrate diet, such as insulin resistance or diabetes. Carbohydrate intake is limited, triggering the body to enter a state of ketosis to burn fat as the main energy source.

5. Class 5 Diet (Special/Specific)

A diet designed to suit an individual's needs based on medical conditions or specific dietary preferences. For example, a low-salt diet for hypertension, a low-fat diet for heart disease, or a high-fibre diet for digestive problems.
These classifications help guide more targeted dietary recommendations according to individual health circumstances and nutritional needs. However, it is important to note that any dietary recommendations should be personalized according to individual needs and health conditions, and should be consulted with a health professional or nutritionist.

III. RESULTS AND DISCUSSION

This research aims to create an Android-based application to control blood glucose levels in Type 2 DM sufferers using an Android-based lifestyle management application. Advances in information technology can support the self-care management of Type 2 DM patients called Selfcare Glucose Management (SCGM).[14]. This application is a development of information technology that is connected to the nursing field and helps Type 2 DM patients maintain their lifestyle.

A. Aplication Design Result

Figure 1. shows the main page of the application after the login process. It can be seen on the main page displaying the patient's personal data in the form of diet class, height, weight and the user's daily calorie needs. At the bottom of the main page displays 4 features of the SCGM application, there are daily food menu recommendations, recommendations for light physical exercise, education about type 2 DM and an alarm feature to reminds users to take medicine or insulin injection.

Figure 1. Main menu of SCGM Apps

This application was created using the Kodular Creator web application. The kodular creator was chosen to simplify the process of creating SCGM applications without the need to compile code from scratch

Figure 2. Sign up page

Before going to the main menu, the user will be asked to fill in the form on the registration page as in figure 2. The user will be asked to fill in information in the form of name, age, height, weight, gender, and daily activity intensity. This information will be used to determine lifestyle recommendations according to user needs, one of which is based on TDEE using equation 3. Apart from that, users will also be asked to fill in their email and password to create an application account.

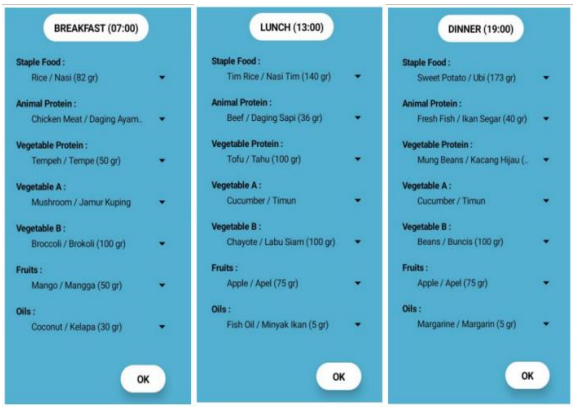

Figure 3. Food recommendation page

Figure 3 shows the main food menu recommendation page, there are 3 meal schedules, namely, breakfast, lunch and dinner. Where in each meal schedule there are several food menu choices consisting of staple foods, animal protein, vegetable protein, option A vegetables and option B vegetables, fruit and types of oils. In each recommended menu there is a recommended food weight measurement based on the user's diet class. The amount of food for each menu can change automatically according to the application user's diet category.

Figure 4. Snacks page.

There is also a page of recommended snacks that users can choose from, where the snacks amount has been determined. The types of snacks on the menu options depend on the user's diet category which has been determined by the application.

Figure 5. Physical exercise page.

Figure 5 shows the user's daily activity which displays the number of steps taken that day and the distance traveled by the user. To complement the features of the SCGM application, an educational feature has also been added to provide education to users about type 2 diabetes mellitus.

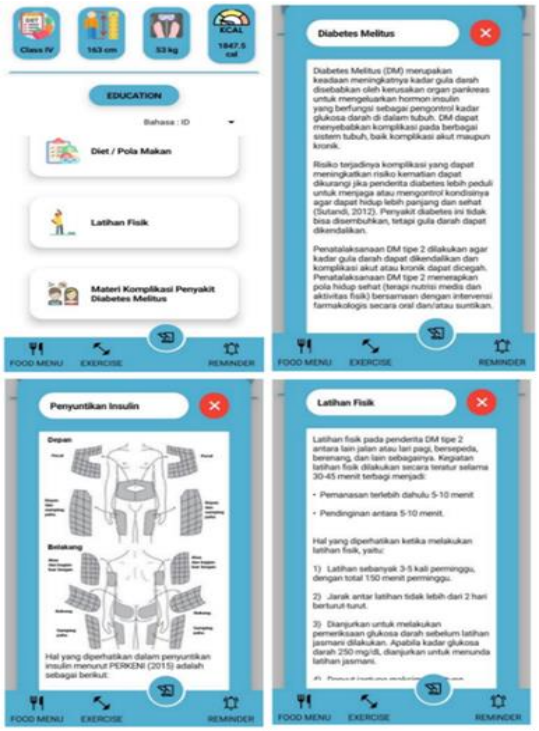

Figure 6. Education page and education material

Figure 6 shows the contents of the education feature, which is material about type 2 diabetes mellitus, such as feet treatment, insulin injection, diet, physical exercise, and complications of diabetes mellitus. Providing this educational material aims to increase the user's understanding of the disease they are experiencing.

If the user is in the process of treatment where he is required to take medication and/or give insulin injections regularly, the SCGM application provides a reminder feature to remind the user of the schedule for taking medication and giving insulin injections.

The reminder page is shown in figure 7. On this page, the user can set a schedule for taking medication and administering insulin injections if necessary, as shown in figure 7(a). If the clock shows the time to take medication or give an insulin injection, the application will provide a notification in the form of a message or animation as shown in figure 7(b) accompanied by a ringtone.

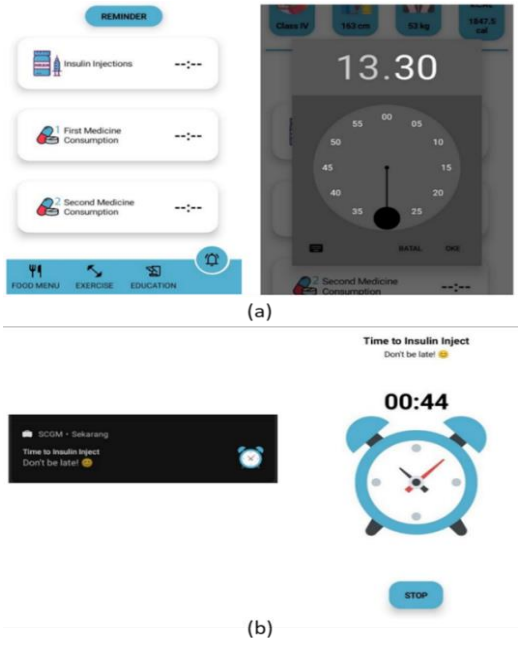

Figure 7. Reminder page (a) alarm setting; (b) alarm notification.

B. Application Decision Result

Determination of diet class and diet variations is done by calculating TDEE based on patient data. Based on the following patient samples, the results of the decisions made by the program designed in this research can be seen.

Table 3. Sample data

Sample No.	Sample data	Decission
1	Name: R****h Age: 48 y.o. Height: 148cm Weight: 52kg Gender: Female Activity: Light	BMR: 1080 TDEE: 1134 cal Class diet: I
2	Name: M*h. R**f Age: 56 y.o. Height: 168cm Weight: 57kg Gender: male Activity: intermediate	BMR: 1734 TDEE: 1994.1 cal Class diet: III

Based on sample data from table 3, a decision on the diet class and calorie requirements (TDEE) of the program that has been created is obtained. Where sample 1 produces data on calorie needs of 1134 calories and is included in diet class 1 which is a diet for users with normal IBW. Meanwhile, sample 2 has a greater calorie requirement, namely 1994 calories. The large calorie requirement is caused by sample 2's body weight being below the IBW value, so sample 2 requires greater calories to gain weight and this is classified as diet class 3.

Table 4. Sample's food menu recommendation

Sample	Breakfast	Lunch	Dinner
R***h (class I diet)	• Tim rice 82gr • Chicken 40gr • Tempeh 50gr • Mushroom or Broccoli 100gr • Mango 50gr • VCO 30gr	• Tim rice 140gr • Beef 36gr • Tofu 100gr • Cucumber or Chayote 100gr • Apple 75gr • Fish oil 5gr	• White bread 96gr • Fish 40gr • Mung beans 15gr • Cucumber or Beans 100gr • Watery apple 75gr • Margarine 5gr
M*h. R**f (class III diet)	• Tim rice 300gr • Chicken 65gr • Tofu 100gr • Mushroom or Broccoli 100gr • Mango 100gr • VCO 30gr	• Tim rice 300gr • Beef 66gr • Tofu 100gr • Mushroom or Eggplant 100gr • Apple 100gr • Fish oil 10gr	• White bread 156gr • Fish 70gr • Mung beans 25gr • Mushroom or Bamboo shoots 100gr • Watery apple 150gr • VCO 30gr

Table 4 shows the recommended food menu for each individual which has been personalized based on the patient's body condition. Individuals in Sample 2 (M*h R**f) tend to receive recommendations for larger food portions than sample 1 (R***h). This is because sample 2 is in diet class 3 which requires a greater calorie intake to achieve ideal body weight. Each menu also provides 2 types of vegetables to choose from. Apart from that, recommendations for oil consumption are also given to meet the needs for omega 3 and omega 6 consumption

CONCLUSIONS

This research is research and development with qualitative descriptive analysis aimed at developing lifestyle applications for type 2 diabetes mellitus sufferers. Based on the results of this research, it can be concluded as follows.

1. Manual measurements have been carried out to test the accuracy of the application in measuring. The results obtained from manual measurements are in accordance with the results of application calculations, this proves that application measurements are worthy of consideration.
2. The functional functions of the SCGM application were successfully executed and the test results were obtained according to the scenario based on the expected functions along with the output results.
3. The validation results for making the SCGM application showed that the application can be used as self-care management for Type 2 DM sufferers in controlling blood glucose levels. It is hoped that this diabetes care application will make several improvements and further developments so that this application is truly effective for distribution to type 2 DM patients in the future.

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