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E-Health Mobile App for Overall Health Tracking – A Proposed Model for Weight-loss and Glucose Tracking

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Abstract

Nowadays there are many mobile devices which consist of applications that are used for communication, socialization, entertainment and similar purposes. The advantage of smartphones, wireless technologies, wearables and other smart devices can be found in the field of e-health and m-health. With the development of the industry of Internet of Things (IoT) there has been a growth of the use of interconnected smart devices whose purpose is to track and improve the human health. However, not many smart devices are concerned with the human health overall. In this study, we focus on the possibility of using a smartphone that is interconnected with other devices to detect, monitor, summarize, and give health advices to the user. We propose an e-health mobile application that behaves as a smart assistant. The application takes into consideration all of the possible health issues that the person may experience with a special focus on weight-loss and glucose level tracking for Type 2 Diabetes. Our expectations were satisfied by normalizing the weight and the glucose level in the blood of the study subject.

Keywords: e-Health; mobile application; smart assistant; type 2 diabetes; tracking; weight.

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1. Introduction

Since 2015 until today the mobile-broadband subscriptions have grown more than 20% annually and are expected to reach 4.3 billion globally by end of 2017, according to the latest report on ITU Statistics [1].

The increased availability of interconnected smart devices such as smartphones and tablets created growth in the mobile applications market. Taking into consideration the fact that smartphones are becoming faster, and have better displays they are also becoming the main tools for education, communication, business and entertainment. With the growth of IoT the smartphones became the central operating tool for the control of the rest of the smart devices in the homes and wearable gadgets. Smartphones are used for controlling home appliances, locking doors and similar. Smart assistants are becoming part of the daily life of the users. There is a wide variety of applications that are operating on the smartphones, however there are not many applications that are working as e-health assistants.

A smartphone can be used to monitor and observe the overall health of the people and provide personalized healthcare. Because of that, in this paper we propose a mobile application that behaves as a smart assistant that detects early health issues and monitors the progress of the person's health. Main part of the application is giving advices to the users about their health issues. The app takes into account the medical history, daily drink and food consumption, level of physical activity, and the total mental and physical state of the human.

In this paper we mainly focus on the physical state of the person, especially in the weight and glucose levels of a person that is at an early stage of the disorder Type 2 Diabetes. One of the essential parts in the general workflow of the application is detecting the level of the health problem, providing solutions and observing the progress of the improvement of the weight and blood sugar disorder. The sections that follow introduce the application in details.

2. Related work studies

E-health Apps recently have an increased interest of use by the general public. There exist many mobile applications with different purposes but same goal, and that is improving the human health.

2.1 Commercial development

The E-health Apps in this group have different ways of advising the users for their health issues.

One of many e-health applications with the purpose of weight-loss and fitness [2] works as a lifestyle companion to track fitness, diet, food and sleep of the users. Another example that has similar purpose as [2] is [3]. The difference is that this app also takes into account the waist measurement and BMI (body mass index). Other E-heath Applications have the purpose of collecting and managing medical history [4]. This application collects data about the doctor visits, MRI (magnetic resonance imaging) scans and similar healthcare documents such as medical charts.

The market also provides diabetes concerned applications [5]. This application keeps logs of the blood sugar levels, insulin doses and bolus for the users' meals. It also keeps track of the food intake which is connected with a nutrition database. The app also summarizes data into graphs and gives options for importing and exporting data. A great addition to this application is that it allows the user to send the detailed reports to their doctor directly from the app.

A healthcare app that works similarly as an e-health assistant is [6]. This app through artificial intelligence and clinically validated content written by the British National Health Service (NHS) provides personalized health information. The app is divided into sections, such as weight-loss, skincare, hair care, body care and general advice, where each section handles specific feature providing different information.

2.2 Theoretical research

Mobile health communication programs and e-Health in general are able to enhance the consumer and provide access to important health information and increase the quality of care as it is described in [7]. Another finding is that there are positive effects of e-Health interventions in palliative care as it is described in [8]. The results show that there is better decision-making, communication, education, and support for patients. As shown in [9], web-based home-monitoring of patients facilitate contact between patients and health-care professionals, and reduce time to remission for patients with inflammatory bowel disease (IBD).

In [10] the use of e-Health web applications and mobile health applications as information communication technology and therapy management for drug monitoring has shown to have many advantages. These include faster booking appointments, better consultation, decision-making, personalization and adherence. [11] provides an overview of the needed elements for self-tracking and e-Coaching with the goal of obtaining healthy lifestyle and health interventions. [12] points out the reasons why some patients dropped out from the e-Health program and those include frustration technology, receiving irrelevant content, choosing other activities, and lacking face-to-face encounters. As shown through the diabetes type 2 prevention program delivered via e-Health the most effective were the interventions through counselor support post-baseline [13].

A study was conducted in the Netherlands about type 2 diabetes treatment with contact between patients and healthcare professionals including both healthy lifestyle adaptations and pharmacotherapy. The results showed that healthcare providers were in charge of making treatment decisions even though a shared-decision making was applied [14].

In the case of [15] it is concluded that the use of mobile phone text messaging, wearable or portable monitoring devices, and applications running on smartphones have positive effects among patients with chronic diseases such as obesity and diabetes. As shown in [16], a mobile health approach is used to collect and monitor the patient data and allow the user to obtain customized response on their smartphone. This also includes the use of sensors that are connected wirelessly to a mobile device.

Another method is shown in [17] that uses an approach of building an autonomous system that can be integrated as part of a wider e-Health application to assess the risk of death in patients. [18] investigates usage and effectiveness of a web-based application to increase healthy behavior in adults with a healthy weight or slight overweight. The results of this work show that there is an improvement in a healthier behavior of the users. [19] has the purpose of guiding patients that have difficulties in their treatment, such as lack of motivation, knowledge and depression.

The case study [20] proposes the use of different devices and an assistant system to help diabetics. Their system is based on a new middleware called tinyUPnP. tinyUPnP works in combination with other proposed underlying protocols: tinyHTTP, tinySSDP, tinyGENA and tinySOAP. Another example [21], uses real-time monitoring system in order to detect and update those cases where patients would require of rapid assistance. The monitoring system in [22] creates diabetes control and predictions of future blood glucose with the use of a system that uses original medical data collected by medical sensor and some data entered manually.

3. Materials and Methods

Our proposed model of an overall e-health app is a cross-platform web-based mobile application that takes into account all of the user’s information and customizes the solutions according to their unique experiences. It also includes the ability for the user to contact a local specialist directly through the application. The design of the application is very simple so that older individuals would have no trouble using it. All of the collected data is summarized into graphs that could be shared with their local doctors. However, the main future is the analysis of the human body weight and blood glucose levels in order to detect health disorders.

The model workflow starts with the user signing up to use the application. Since we assume that the person is going to use the application on his personal smartphone, we only ask for username and password and do not perform additional authentication when the person logs in. After that the user fills in the main information that will be used for analysis and the shaping of the healthcare. The results are compared with previous results and graphs are displayed as a summary.

It is important for the application to have information about the activity factor of the user, hence we are adding the possibility of wearable usage that will count the steps of the user. This will allow us to generate the activity factor value and set the macronutrients values uniquely for the user. As a result, we obtain more information about the weight-loss and blood sugar level decrease plans.

3.1 Why e-health app

The fundamental purpose of the e-health mobile application, is to detect health problems or body changes by in-depth analysis and comparison of the individual’s collected data. Once health issues are detected, the user will be educated about the matter, obtain solutions given by the app or schedule an appointment with a health specialist through the application.

3.2 Model workflow

The algorithm that we propose, requires information such as, gender, body shape (somatotype), age, weight, height, glucose test, A1C test results and calculate or enter BMR value. This information is important so that we can determine if the body weight is normal and if the person has diabetes mellitus type 2 which is closely related to being overweight.

Type 2 diabetes is the most common type of diabetes around the world. This can be a result of bad lifestyle and genetics. The lack of exercise and bad diet such as soft drinks with high concentration of sugar and certain types of fats can cause this type of diabetes. Also, it can be caused by high stress levels.

3.2.1 BMI and BMR

BMI or body mass index is measure of body fat based on height and weight that applies to adult men and women which we are using to determine if the person is underweight, normal weight, overweight or obese. We use the Adolphe Quetelet's formula in equation 1:

$$BMI = \frac{mass_{kg}}{height_m^2} = \frac{mass_{lb}}{height_{in}^2} * 703 \qquad (1)$$

If the BMI value is less than 18.5 then the person is underweight. The normal BMI range is between 18.5 and 25, and the overweight range is from 25 up to 30. However the most severe case is with BMI above 30 that means the person is obese [23].

After we obtain the knowledge about the weight condition of the user we calculate the BMR with the purpose of giving suggestions for changing the food and drink consumption habits. BMR or basal metabolic rate is the amount of energy expended while at rest in a neutrally temperate environment. We used the Mifflin St Jeor Equation as show in the formula 2:

BMR = 10 x mass (kg) + 6.25 x height (cm) – 5 x age (years) + s, where s is +5 for males and −161 for females(2)

Each user will need to do HbA1c, or glycol-hemoglobin test at their local hospital so that they can enter the value in the app. This test measures the percentage of red blood cells with a sugar coating and shows the person's average levels of blood glucose over the past 3 months. On the other hand the glucose test shows the current level of sugar in the blood. This information is essential so that we can determine if the person has diabetes type two and we can shape the solutions according to the user.

3.2.2 Somatotypes

The American psychologist William Herbert Sheldon categorized people's bodies according to the extent to which their physique conforms: Endomorph, Mesomorph and Ectomorph. He named these types after the germ layers of the development of the embryo: endoderm, mesoderm and ectoderm. These body types are also known as somatotypes [24].

The person who has ectomorph body type has a linear, thin, tall, fragile, flat chested physique and has trouble gaining muscle. These people usually are introverts, tense, secretive and closed body posture. The mesomorph somatotype has a body physique that is very athletic, triangular and strong. Moreover the muscle gain for this type is very easy. Their psychological traits are adventurous, assertive, direct and dominant. Endomorph body physique is very round, short, soft and these people have difficulties losing weight and building well defined muscles. They have characteristics of a caring, affectionate, slow and less confident person [25].

Since person's somatotype also defines the metabolism of the people this is closely related to the digestion and the hemoglobin in the blood and the diabetes disease. Ectomorphs have abnormally good metabolism and are less prone to diabetes. Mesomorphs have good metabolism however they are prone to diabetes type 2 if they don't pay attention to their diet. Endomorphs are more prone to diabetes type 2 by being compared to the other somatotypes, but this doesn't mean that each endomorph is going to have this disease. It highly depends on the lifestyle and the genetics.

3.2.3 Forms

We use all of the information mentioned before to shape the solutions uniquely to each user. The form that the user fills in the mobile app in is shown in Figure 1.

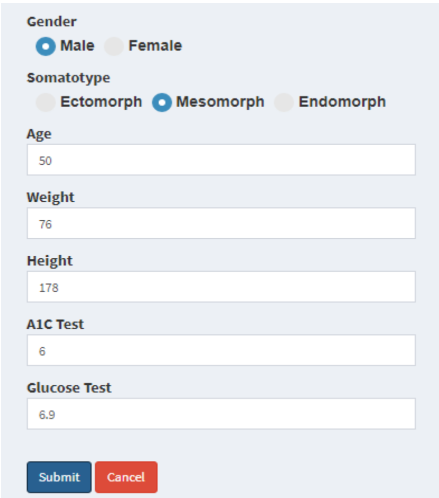

Figure 1: General information form

Next the user is guided to the following page where he or she needs to enter the activity factors as show in Figure 2. The general activity factor starts from the value 1.2 for sedentary humans up to the value of 1.9 for athletes. For the protein range the activity factors start from 0.5 up to 1.5. Lastly, the users pick the option for the fat range that starts at value 0.25, which is the minimum, to the maximum of 0.45. These values are assigned uniquely depending on the previously obtained data for the user [26].

The user can either select their own activity factors or use a wearable to determine these levels more correctly. As it can be seen in Figure 2 we use general activity factor and two separate factors for the protein and fat intake.

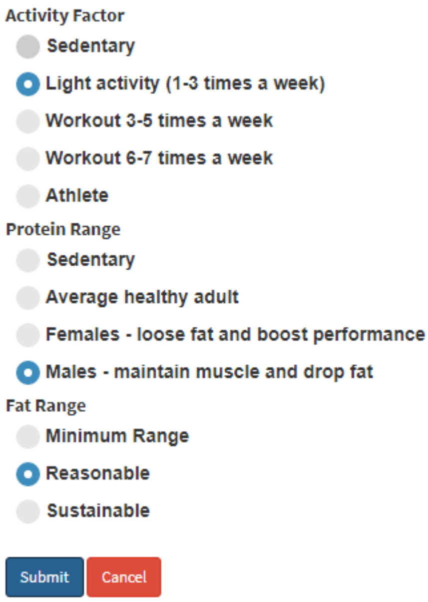

Figure 2: Activity factors form

These factors help us determine the food and drinks intake of the person. The app calculates the protein, fat and carbohydrates in grams which the user needs to take per day.

3.2.4 Calculation of macronutrients

Macronutrient makes up the chloric content of food. Those are protein, carbohydrates and fat. The systematic investigation of the gross energy content of food and of the availability of that energy can be credited to Rubner in Germany and to Atwater in the United States [27]. They measured the heat of combustion for each macronutrient. Combustion is chemical breaking down into carbon dioxide, water and heat.

The average heat of combustion for lipid (fat) is generally known as 9.4 kcal per gram. This is the same case in humans and it can be rounded at 9 kcal per gram. On the other hand, the average for carbohydrate is given as 4.2 kcal per gram gross energy and for humans is it rounded at the value 4. Same as in carbohydrates, the average net energy for calories which is rounded at 4 kcal per gram [28].

Following, we are going to describe the macronutrients calculations in the case of 50 year old male of height 178cm, weight 76kgs (167.5lbs) , body type Mesomorph, A1C test 6% and current glucose level 6.9 mmol/L. This male is slightly active daily, so their unique activity factor value equals 1.375. The goal of this male is to lower glucose levels, maintain muscle mass and drop fat. Hence, the activity factor value for the protein range is 1.25. His goal is to loose fat in a reasonable pace so their activity factor value from the fat range is 0.35. Their BMR is 1627.5 and their BMI is 23.99. To lose weight at a steady pace i.e. to lose one pound of fat per day the person needs to lose 3500 kcal per week which is 500 kcal per day.

The daily protein, fat and carbohydrates intake in grams are calculated using the following formulas:

$$\text{Total calories} = \text{BMR} * \text{Activity factor} \quad (3)$$

$$\text{Goal calories} = \text{Total calories} - 500 \quad (4)$$

$$\text{Protein intake} = \text{weight (lbs.)} * \text{protein range factor} \quad (5)$$

$$\text{Fat intake} = \text{weight (lbs.)} * \text{fat range factor} \quad (6)$$

$$\text{Carbs intake} = (\text{Goal calories} - \text{Protein intake} * 4 - \text{Fat intake} * 9) / 4 \quad (7)$$

4. Results

We applied the algorithm by creating a cross-platform web-based mobile application that works on smartphones. The application displays the results of the 50 year old male's body state as shown in Figure 3.

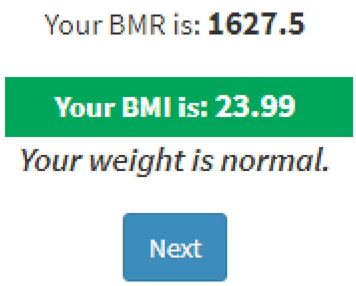

Figure 3: Results for BMR and BMI

The results of the daily macronutrients intake for this user are shown on the application (Figure 4).

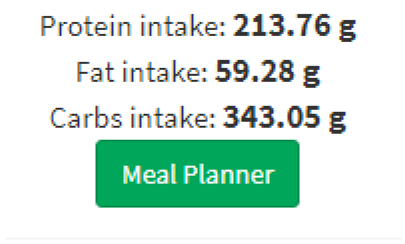

Figure 4: Daily macronutrients

The application was used on a 50 year old adult male that was at the early stages of Diabetes Type 2. After the patient was diagnosed with Type 2 Diabetes the medical specialist suggested him to take medications. However, the patient refused the medication and agreed with the doctor to try to manage the blood sugar levels by using proper diet and exercise. The doctor advised the patient to measure the blood sugar levels at least once a week so that he can see and evaluate the progress. The study subject was measuring their blood sugar level using Accu-Chek Active [29] and entering the numbers in the application. The graph below shows the overall progress in the time period from January to December 2016.

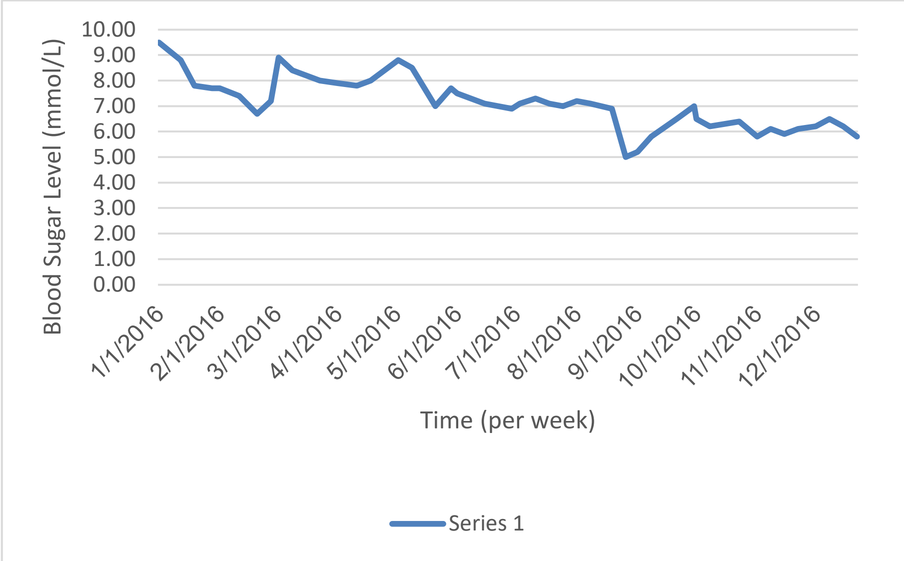

Figure 5: Weekly blood sugar levels of 2016

The blood sugar starting point on first of January 2016 was 9.5 mmol/L that is above the normal range which is below 6.9 mmol/L (125 mg/dL) for people who are not fasting [30]. As it can be seen on the graph the blood sugar has been decreasing steadily with few alerting raises in March and May with values 8.9 and 8.8 respectively. Since October until December the glucose levels in the blood is in the normal range. These results are satisfying the expectations for decrease of the blood sugar levels. The medical specialist received the graph, advised the patient to keep up with the diet and check the blood sugar at least once a month. The monthly results for the next year are the following:

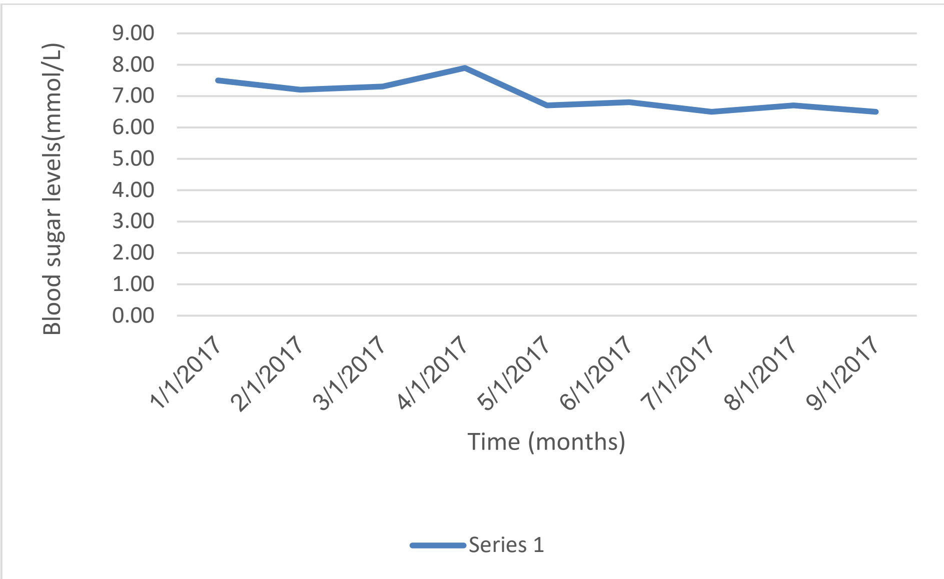

Figure 6: Monthly blood sugar levels of 2017

From the graph above we can see that the subject has normalized their blood sugar levels throughout most of the year of 2017. However, the timespan for such results may vary from one individual to another, depending on any medical history and any other information that may account for certain blood sugar abnormalities.

5. Discussion

The e-Health application efficiently guided the user to a proper diet and enabled them to track their progress of weight-loss and blood sugar levels decrease. It also enabled the users to note the macronutrients that were shaped to their own unique needs. Our data processing approach offered simpler and more accurate detection of health issues. The health status history graphs would allow us to determine different diagnoses with higher level of correctness and suggest healthcare preventives.

Opposite to [2] our work takes into account the person's body shape type by letting the user be educated and pick the correct somatotype (Ectomorph, Mesomorph or Endomorph). The lack of face-to-face consultation as it was noted in [12] will be solved in the future by adding an option in the application for video-conferences with medical specialists. Similarly as in the work in [20] we will implement options for guiding patients that have difficulties in their treatment such as lack of motivation, knowledge and depression.

6. Recommendations

This study found that there is an alternative way of treatment for the disease Diabetes Type 2. Proper diet can enable the patients to normalize the blood sugar levels at the early stages of the disease. The use of mobile applications for treatment and tracking of glucose levels should be increasingly used by doctors and patients in the future. Furthermore, applications that operate on other smart devices can be used daily, weekly or monthly for detection and tracking of the human health. As a result, this can enable inter-communication between devices for better assessment of the findings.

One of the limitations of this research study was the sample size because it included only one male of age 50. With the increase of number of people to be analyzed we can determine if there are differences in the results based on gender, age, medical history and physical activity. Another limitation is the fact that we didn't include a stress factor that determines if the stress level of the patient was decreasing or increasing as time progressed. All of these limitations can be fixed and explored in our future works.

7. Conclusion

The use of the e-Health application satisfied our expectations by guiding the user to a proper diet and by normalizing their glucose levels. As a result the patient was healthier and lost excess weight. Our data processing and tracking approach offered simpler and more accurate assessment of the results. Adding more information about the health history in the application would enable us to determine different factors that can result in better diagnoses.

As a future direction, we will be working on communication with a wearable device, which will be used to obtain data about the person's walking, running, cycling and sleeping patterns. These patterns will be used to determine the activity level (factor) value that will be used for creating a unique meal plan. Our main goal is scaling this application to obtain additional health information and deliver personalized solutions for the overall human health. Also, in the future we are planning to enable this application to be synchronized with other smart devices such as in the example of [31].

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