Experimentation of Gamification for Health and Fitness Mobile Application

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***Abstract*—Lack of fitness is a growing problem in recent years and it can lead to many non-infectious disease with heart disease as the number one killer. There are many health application available on mobile phones. However, the applications available on the market right now are usually only able to do a specific task, such as calorie tracker or fitness tracker or blood pressure tracker. To maintain or improve health and fitness we need to take into account combination of several factors, which require users to use different applications. In this paper, we developed a mobile application that has combined health-relevant features: a calorie tracker to help user loss or maintain weight, blood pressure and pulse tracker, and fitness tracker. These are three essential factors to help user live a healthy life and prevent heart disease. In addition, we also implemented a simple gamification feature to increase users' motivation to use the application and do the exercises. The experimentation and findings showed that the proposed solution would be beneficial to help people keep a healthy heart and go fit.**

Keywords: Mobile Application, Blood Pulse, Calorie Tracker, Health Status, Recommender, Gamification

I. INTRODUCTION

Life is all about balance. Balance between family and work, working out and laying around, as well as between food intake and exercise. However, according to a recent study by Rachmi, Li and Baur [1], the growth in the occurrence of obesity or overweight among Indonesian adults from 1993 to 2007 was much higher compared with that globally, with 11% among men and 13-16% among women while the occurrence of obesity globally rose by about 8.1% in men and 8.2% in women from 1980 to 2013.

As cited in The Jakarta Post [2], in 2010, Jakarta was among the top three provinces with the highest number of overweight and obese children. Only Southeast Sulawesi (14.7%) and West Papua (14.4%) are higher than Jakarta (12.8%). However, according to the Health Ministry, the trend of obesity is worrisome. In 2013, the overweight among children was 30.1%.

Obesity itself can lead to several non – infectious diseases, with the number one killer is cardiovascular disease [3]. This kind of disease needs a high cost treatment, which ultimately will lead to high medical burden for the Indonesian government. Thus, Indonesia is facing obesity problem and the growth in the number of obesity becomes a major health concern in Indonesia.

Obesity is usually caused by an energy imbalance between calories consumed and calories burned. Obesity can occur if a person has high intake of energy – dense food and high fat food. In addition, an increase in physical inactivity due to the increasingly sedentary nature of many forms of work can be another factor. People who work at the office and sit for a long time can be exposed to obesity. In Jakarta, more and more people use public and personal transportation rather than bicycle or on foot. According to the WHO, fast food and food with high fat and sugar has been more popular among people in the big city compared to people in small town [4]. Furthermore, Indonesian also eats food that contains high fat and sugar. This can happen because most of the Indonesian have no or poor knowledge and awareness about healthy food [5].

There are several ways to get fit and keep our heart healthy, one of them are by eating clean and healthy, reducing calorie intake and exercise regularly [6]. In general, all exercises are good for health. The best exercise for heart is aerobic exercises, such as jogging, running or swimming. For senior citizens it is advised to have a low- intensity exercise. However, these kinds of exercises would not directly reduce the weight. In addition, they also have to monitor their calories intake.

Achieving a balanced diet is one of the most important things to get fit. Thus, one method to tackle the obesity problem is by tracking calories intake and burned. Over the years, people are becoming more health conscious. This trend lead to many smartphone develops health related features. For example, Samsung launched the S-Health then Apple also launched similar feature.

According to Pew Research Center, the number of mobile phones penetration in Indonesia is growing and was amounted to 21% in May 2015 [7]. Thus a natural thing to track calories intake and burned is by keeping a food journal on the phone. This is the reason why we believe that developing a calorie tracking application is a way to tackle the growing issue of obesity in Indonesia. Having an application that can track how many calories taken and burned, can help people to stay in shape. The smart phone can act as a food journal and give notification to the user about what exercises to do and food to

eat. Furthermore, from interviews with two medical doctors, blood pressure monitoring, aerobic exercise and balance diet plan could help prevent heart disease.

Currently we can find many applications that could keep track of daily food intake and calories burned. We can also find many applications that could track exercises and their history separately. Furthermore, in order to check pulse, usually we have to use other application. However, to achieve a balanced diet, we need to keep track combinations of different activities. For instance, to maintain body weight we need to calculate both the calories intake and the calories burned during a particular period of time. Therefore, having an apps which can monitor combinations of physical activities, calorie intake, sleep pattern, blood pressure and pulse would help user to maintain a balanced diet to get fit and keep the heart healthy.

In order to make the users more engaged and motivated to use the application we also implement gamification, which is is the use game elements or game mechanics to non-game applications. In this paper, we designed and developed a mobile application to monitor combinations of physical activities, calorie intake, sleep pattern, blood pressure and pulse, and using them to determine the user's health status, as well as to give a recommendation to make the user healthy.

The rest of this paper is divided into the following sections: section II reviews the health related terms and knowledge base used in the application and the related works; section III describes the design of the solution and experiments; section IV explains the experiment results; and finally section V concludes the paper.

II. PRELIMINARIES

A. *Obesity and Health Issues*

The Centers for Disease Control Prevention (CDC) defines obesity as a condition that is associated with having higher body weight than what is considered as a healthy weight for the specific height [8]. This abnormal or excessive weight might have a negative effect on their health.

World Health Organization (WHO) uses Body Mass Index (BMI) to differentiate between people who suffer overweight and obese. According to WHO, person can measure their body mass index (BMI) by dividing their weight in kilogram to the square of height in meters. The WHO defined body mass index with the following criteria [9]:

1. A BMI >= 25 is overweight
2. A BMI >= 30 is obesity
3. A BMI >=40 is severely obese

According to WHO (2012), cardio vascular disease has become number one killer in developing countries and the world including Indonesia. It killed around 17.5 million of people in 2012 around the world. To sum up, it contributes 3 in every 10 deaths [10].

B. *Relation between Cardiovascular Disease and Lack of fitness*

The cause of coronary heart disease is because the heart's blood supply is blocked or interrupted by a build-up of fatty substances in the coronary arteries. Over time, the walls of your arteries can become furred up with fatty deposits. This process is known as atherosclerosis [11]. Atherosclerosis can be caused by lifestyle factors and other conditions, such as:

- smoking
- high cholesterol
- high blood pressure (hypertension)
- diabetes

Coronary Heart Disease (CHD) or sometimes called as ischemic heart disease is a condition when the heart's blood supply is blocked by substances. This build-up of substances can reduces blood flow to the heart tissue. As a result, the heart muscle has to work harder to pump the blood through the coronary arteries. This can cause blood pressure to rise. Therefore, record of a blood pressure can be a first step in detecting heart disease [12].

Gradual blockage of main coronary artery will cause the heart to weaken. When the heart weakens, it fails to pump efficiently and difficult to supply heart muscle with sufficient oxygen and nutrients. Therefore, the heart tissue is starved of oxygen and nutrients and heart muscle will die and cause a heart attack. Aerobic exercise is one way of lowering blood pressure and control obesity [12]. Aerobic activity helps to lower blood pressure, blood cholesterol and control obesity. Thus, exercises can decrease the risk of CHD.

C. *Existing Solutions*

These existing solutions were divided into three categories of application, such as blood pressure monitoring, calorie tracker and fitness application. We chose two applications from search engine top results in each category and analyzed them for gap analysis.

Blood Pressure Monitoring Application

BP Monitor. This application lets user to input information such as medication, weight, height, glucose, temperature and blood pressure. Then uses this data to make a graph and store it as a statistic. It allows user to look at history for blood pressure recorded in the last few months or years. This application also allow user to export/ email the data.

Smart Blood Pressure (SmartBP). This application has a simple interface. It allows user to input systolic, diastolic, pulse, as well as weight and height for BMI calculation. The recorded data is then stored and can be viewed in a graph. This application is simple yet do the task for user who would like to monitor the blood pressure.

Calorie Tracker Application

MyFitnessPal. This application allows user to keep a log of food eaten. It has a big database which allow user to find the food. In addition, MyFitnessPal can scan a barcode on the food packaging to get the information of the food. It also has a

calorie meter, therefore user is more aware of how many calories have been taken. It also has an exercise database. This application acts a calorie diary for people who would like to control their weight. MyFitnessPal has extra features as well, such as food recipes, community and blogs, as well as a way to connect with friends.

FatSecret. This application is dietary diary to keep track of calories intake and burned. It also has food and exercise finder, barcode scanner, weight tracker, diet calendar, sleep tracker and community. FatSecret has a simple interface design, it allows user to keep it simple. However, it serves its main purpose as a diet diary.

Fitness Tracker Application

Nike+ Running. This application can track running routes, including average speed, burned calories, running duration and friends. The plus point of Nike+ is that it can check weather. It also provides a log history.

Strava. This application can track both running and cycle. It also has a log history system. It can also record time, distance and pace. One main plus point of Strava is that "Challenges", if user manage to win the challenges user will get badge. This unique feature can motivate user.

The main weakness of the applications above is that they are too focused on some specific purposes such that they are not good enough as a health promoting application. Heart disease prevention involves several factors, including diet, fitness and blood pressure checkup. Reflecting on the analysis of existing solution, none of the solution is designed solely to prevent heart disease. There are features, which are essential for heart disease prevention, and there are features which are not necessary from each application. Therefore, each solution will be the base to develop a solution to satisfy the condition.

Based on the identified problem and interview with health expert, the proposed application, which we call GoFit, was composed of blood pressure, calorie and exercise monitoring. A feature for blood pressure monitoring is useful for blood pressure screening. In this way, it can identify people who are at risk. The proposed application also provide food diary. It acts as calorie journal for people who would like to have a diet plan, because a good diet plan is vital to a healthy heart. Exercise in overall can improve the quality of living. Exercise helps people to live a health life, especially aerobic activities. These aerobic activities also include jogging and running. As an additional feature, heartbeat can indirectly picture the electrical impulses of the heart. This conduction of electrical impulses can mirror a healthy heart. Therefore, the author is going to propose a prototype with features, which include blood pressure monitoring, calorie and exercise journal.

III. Design of Solution and Experiments

A. System Architecture

The application was developed using a Model View Controller (MVC) system architecture. This model was used to handle the flow of data in the application as shown in Figure 1.

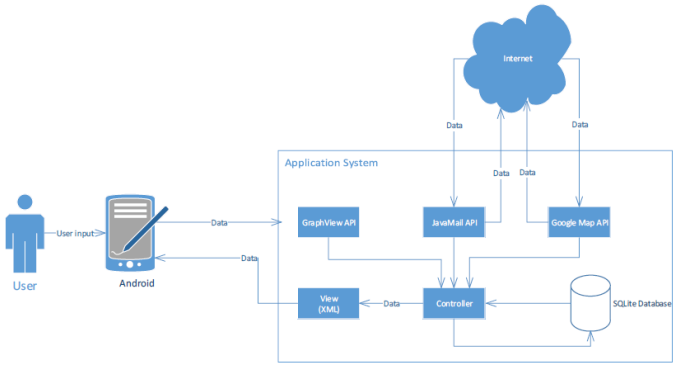

Fig. 1. System Architecture

Figure 1 consists of the following components.

User represents a customer who uses the GoFit application. User can do several activities such as, input calorie intake, exercise, blood pressure monitor and check BMI.

Model, which was developed using SQLite Database, represents the data and information that is being used in this GoFit application. In object oriented programming practices, model is the object used to set and get data from database. Model component holds the data to make the system works.

View represents the data that is going to be shown for user as a User Interface. In this part, the data such as calorie intake and burn, blood pressure graph and history are shown using User Interface components provided by Android. Since the author use Android as the development, most of the view was written in Extra Markup Language (XML).

Controller represents the programming logic for manipulation of data. As part of the MVC architecture, controller acts as a connector between user and model. It handles all of the logic of GoFit application and receives the requests from the user. Controller takes input from user then processes it with data from the model and provides the output for View to be shown to user.

API (Application Programming Interface) is a software library, which help programmers to build software application. API makes it easier for programmers to build applications.

B. Recommendation Rules and Algorithms

Figure 2 shows how the application handles the recommendation activity. When user open recommendation page, the application will check the database to get the information about the sleep, blood pressure, etc. If the information is not available, the user will be asked to input the information. Then this information will be applied to the health rule database in the program to determine user health status. After the health status of a user is known, this status will be applied to recommendation rule database to determine the best recommendation for the user.

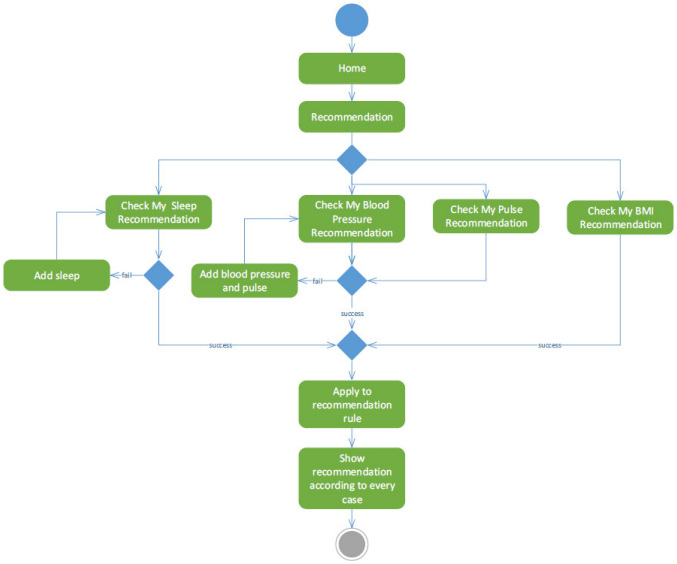

Fig. 2. Recommendation Activity Diagram

The following is the list of algorithms to determine calorie need for each user BMI, blood pressure and pulse category as well as the amount calories burned from each exercise according to every case specific to a user condition. The application uses the medical knowledge base from interview with medical doctors and convert it to if-then rules. The details of the algorithms can be found in [13].

- Algorithm to determine Daily Calorie Need for User

  Get user age, gender, activity level

  If user age, gender, and activity level match with the table then return result =”basic calorie need”

- Algorithm to determine BMI Category Level

  Get user weight and height

  BMI = weight/ height * height

  If BMI <=25 then category = “underweight” then result = “Being underweight could be…”

  If BMI >18.5 and <25 then category =”healthy weight” then result =”keep the good work…”

  If BMI >=25 and <= 30 then category =”overweight” then result =”The best way…”

  If BMI >30 and <40 the category =”obese” then result =”the best way to lose weight…”

  If BMI >=40 then category =”severely obese” then result =”find a doctor…”

- Algorithm to determine Blood Pressure Category Level

  Get systolic and diastolic

  If systolic <= 120 and diastolic >= 80 then bp is “normal” then the recommendation is "Keep your blood pressure level healthy by doing: exercise, healthy eating, maintain weight, limit alcohol intake and avoid smoking"

  Else if systolic between 120-139 or diastolic 80-89 bp is “pre-hypertension” then the recommendation is "You should be able to lower your blood pressure by adopting healthy lifestyle"

  Else if systolic between 140-159 or diastolic 90-99 bp is “high blood pressure stage1” then the recommendation is "Seek medical attention. You will be offered medication to lower your blood pressure if you have existing or high risk of cardiovascular disease.”

  Else if systolic >= 160 or diastolic >=100 bp is “high blood pressure stage2” then the recommendation is “You require medication to lower your blood pressure"

  Else “hypertensive” then recommendation is “Emergency Care Needed”

- Algorithm to determine Pulse Category Level

  If pulse between 60-100 then pulse is “ normal” then the result is "Get more physical activity to maintain heart muscle in best condition"

  Else if pulse < 60 {

  If activity level is active and pulse >= 40 then

  If pulse is “normal” then the result is "Get more physical activity to maintain heart muscle in best condition"

  Else pulse is “too slow” then the result is “Bradycardia is a condition where the heart rate is too low, typically less than 60 bpm. This can be the result of problems with the sinoatrial node, which acts as the pacemaker, or damage to the heart as a result of a heart attack or cardiovascular disease”

  }

  Else if pulse > 100 then

  If pulse is to “fast” then result is “If the heart rate is closer to 150 bpm or higher, it is a condition known as supraventricular tachycardia (SVT). In SVT, your heart’s electrical system, which controls the heart rate, is out of whack. This generally requires medical attention. “

- Algorithm to determine Calories Burned

  Get duration exercise

  Query get exercise calorie for a particular exercise

  Check exercise calorie

  Query get exercise calorie according to user weight

  If Exercise calorie = query result then return the actual calories burned for the specific duration

- Algorithm to Measure Heart Rate using camera

  Take a video of the finger tips

  Calculate the brightness from each frame.

Determine average brightness value.

The average brightness is compared between frames to get the point of one heartbeat.

Only frequency between 0.667 – 3.833 Hz will be calculated. This is to allow detection of human heartbeat that can be found between 40 and 230 bpm.

Every 0.5 seconds, estimates heart rate using 3 methods: FFT (Fast Fourier Transform), peak detection and smoothing.

Find highest peak then translate peak index to an FFT vector index.

Get the peak frequency in bpm that corresponds to highest point.

C. *Gamification Feature*

Gamification is the use game elements or game mechanics to non-game applications with the purpose to make users more engaged and motivated to use the applications. There are many possible game elements or game mechanics or their combinations that can possibly implemented to make the GoFit application more interesting for users.

As of the moment, we only implemented and experimented with a simple challenge feature. The following is the list of challenges that are implemented for this study. In order to use this feature, the users should select a specific challenge that they want to do. They are recorded in personal record database.

Run/Walk Challenge	Type
100 steps	yes/no
1000 steps	yes/no
5k	yes/no
10k	yes/no
5k under 30min	yes/no
10k under 1hr	yes/no

D. *Experiments*

We conducted several tests and experiment as follows. The first was a unit testing to know whether all of the application functionality works well as it should be.

Then we did a user acceptance testing by gathering 10 participants to test the application. All of these participants were university students. This testing was conducted to test whether all of the application features works as it was designed to be. The testing was done by allowing the participants to use the application on hand and rate the functionality, including the challenge gamification feature. Then the survey participants score the application functionality in the scale of 1 to 5, while using the scale of 1 to 4 for the gamification feature. The user acceptance testing took around 30 to 60 minutes for each participant to test and rate the application.

Finally, we conducted an experiment to compare the application's heart rate measurements with one of the leading applications for measuring heart rate, called Instant Heart Rate. This test was done to find out whether the method that we use to measure the heart rate is as accurate as that of the leading application.

IV. PROTOTYPE AND RESULTS

Figure 3 shows the login screen of the application and its dashboard screen. When the user uses the application for the first time, user will come to login screen. After register and login the user will be directed to the dashboard where user can do all the functions of GoFit. The amount of calorie left is the amount of calorie required per day by each user. The amount is calculated according to user age, gender and activity level.

Figure 4 shows the calorie and running tracker screens. User can insert both calorie intake and expenditure in this application. Then the picture on the right shows how user can input calorie expenditure.

Figure 5 shows the blood pressure and pulse measurement graph. User can also input blood pressure and pulse measurement on this page. The pulse measurement can be entered and measured using the camera as well, the user only need to place the finger on top of the camera.

Figure 6 shows the screenshot of the gamification record scoreboard. Bold = challenge completed. Grey = challenge is yet to be completed.

Figure 7 shows that 80% of the participants think that features in GoFit are very useful and easy to navigate through the application. Figure 8 shows that 70% of the participants believed that GoFit is very beneficial to help people prevent heart disease and Figure 9 shows that 90% of the participants agree that GoFit can improve health awareness.

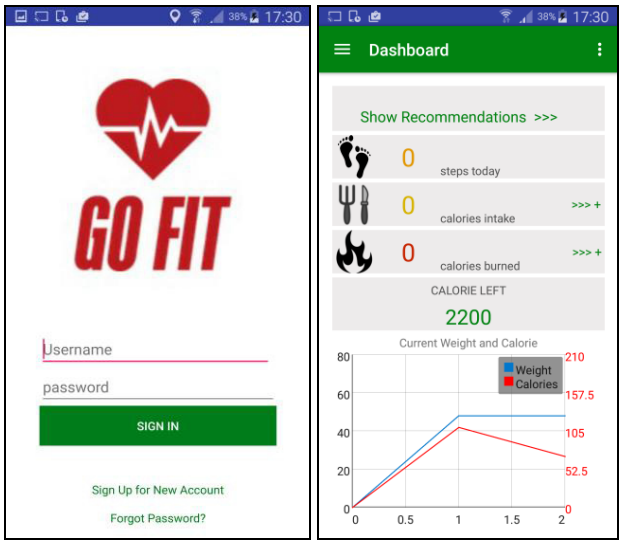

Fig. 3. The Login screen and the Application's Dashboard

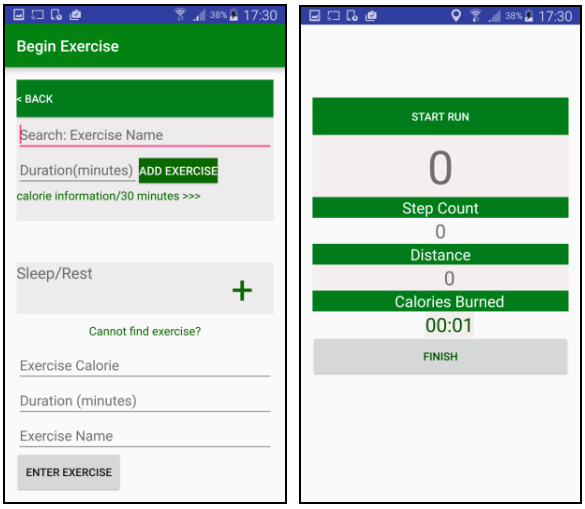

Fig. 4. Calorie and Running Tracker

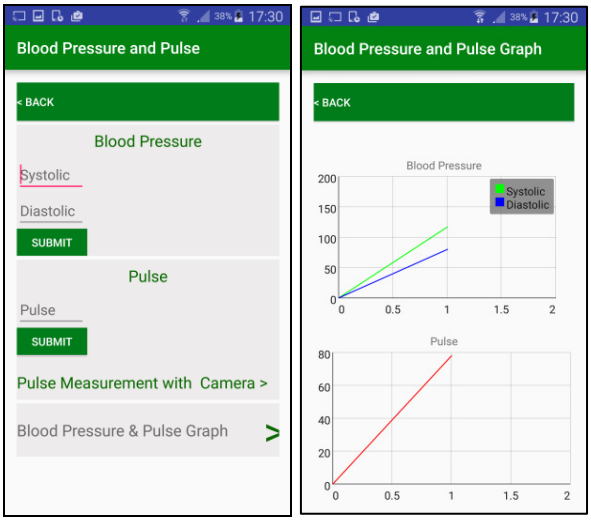

Fig. 5. Blood Pressure and Pulse Measurement Graph

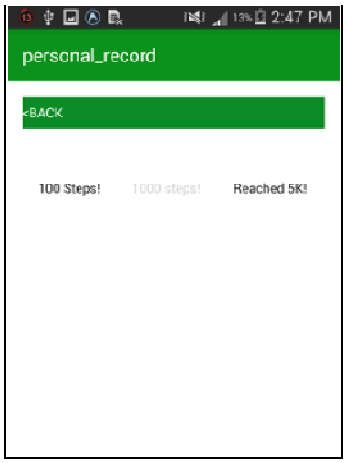

Fig. 6. Gamification record scoreboard

The experimentation of the gamification feature, which consists of some simple challenges, was done to measure the interestingness, addictiveness, and effect of the challenge features for exercise motivation. Figure 10 shows that all participants agree that the challenge feature was interesting. Figure 11 shows that 90% of the participants agreed that the challenge feature is addictive. Figure 12 shows that 80% of the participants agree that the challenge feature can increase exercise motivation.

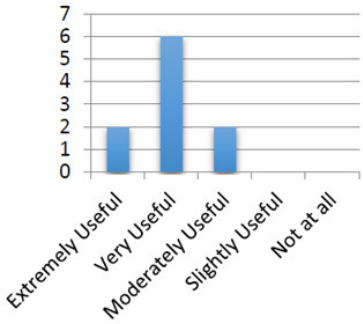

Fig. 7. Response whether the features in GoFit useful

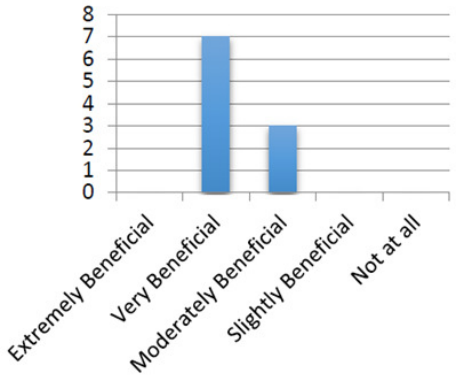

Fig. 8. Response whether GoFit is beneficial to prevent heart disease

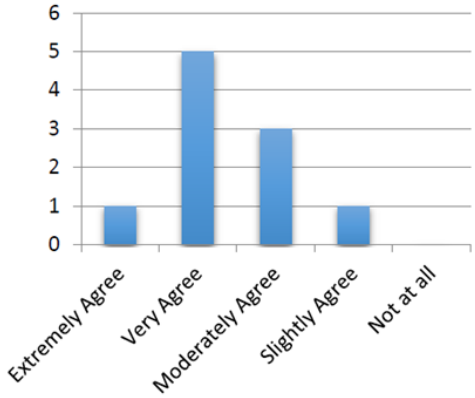

Fig. 9. Response whether GoFit is able to improve health awareness

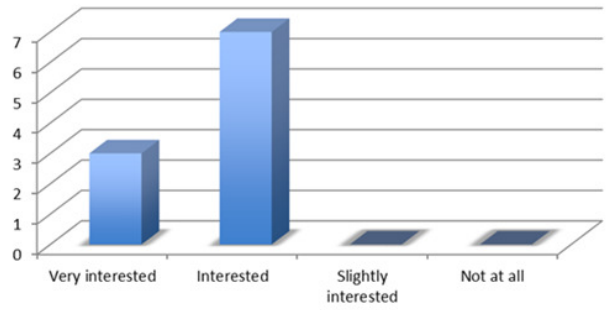

Fig. 10. The interestingness of the challenge feature

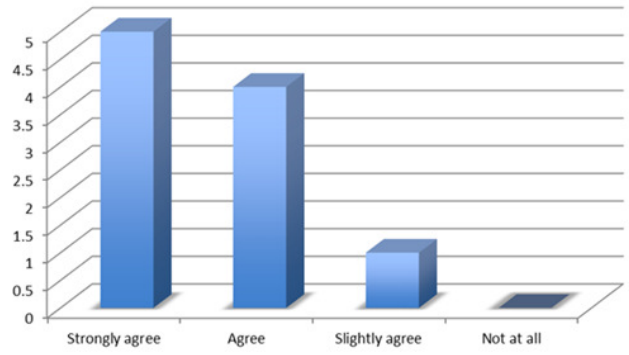

Fig. 11. The addictiveness of the challenge feature

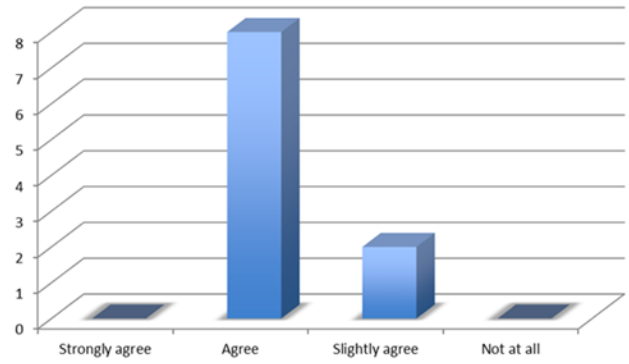

Fig. 12. The challenge feature can increase exercise motivation

In a study by Coppetti, et al. [14], they found substantial performance differences between different heart rate measuring apps. Thus, to measure the accuracy of the implementation of algorithm for heart rate measurement using camera, the application measurement is compared with similar application called Instant Heart Rate, which is currently claimed to be the most accurate mobile heart rate monitor application [15].

During testing, we took ten (10) readings from both applications and calculate the averages. This experiment was done under same condition, such as from same finger, person, under constant light intensity and position. Figure 13 shows the heart rate measurements comparison. The Instant heart rate gave an average of 80.6 and GoFit gave an average of 77.7. T-test calculation on the two independent data samples in Figure 13 yield a T value of 0.4158 (2-tailed). The critical value for 18 degrees of freedom and the 0.05% error from the T table is 2.013. Since the T statistic value is smaller than the T table value, this indicates that the means of the heart rate measurements of the two applications are not significantly different. Thus, GoFit and Instant Heart Rate gave similar heart rate measurement results.

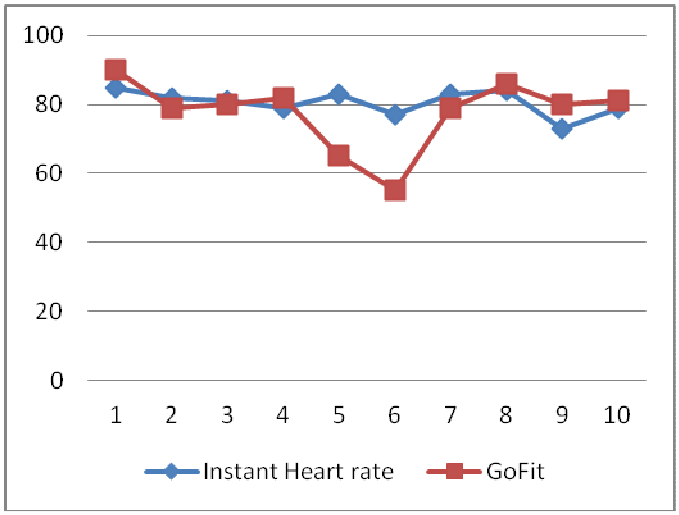

Fig. 13. Heart Rate Measurements Comparison

V. CONCLUSION

Obesity is highly related with lack of fitness and non-infectious disease such as heart problem. People often have difficulties to maintain balance between calorie intake and expenditure. In this paper, we developed and experimented with an application that has a calorie tracker feature. Furthermore, in order to check the health of the heart, the application also has a blood pressure, pulse, and BMI measurement along with recommendation for different cases. In addition, we also implement a simple challenge gamification feature to engage and motivate the users to use the application.

We also compare the heart rate measurements of our implementation of the algorithm to measure heart rate using camera with those of similar application called Instant Heart Rate. Statistical test result indicates that the means of the heart rate measurements of the two applications are not significantly different.

According to the analysis of the user's testing, the application flow is well defined and receives good feedbacks from the participants. This application also provide a calorie, blood pressure and pulse journal. This calorie journal functionality allow user to log both of their calorie intake and expenditure. Then, the blood pressure and pulse log allow user

to record daily measurement, which beneficial for high blood pressure patient. Patient with high blood pressure is able to share blood pressure reading since his/her last visit to the doctor. Thus, patient is ready with the essential information for doctor.

All participants agree that the challenge feature was interesting. In addition, most of the participants agreed that the challenge feature is addictive and can increase exercise motivation. Thus we hope that Go Fit can be the solution for people who seek to maintain their weight, get more fit and keep the heart healthy.

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