Angiology: Open Access

Development of Behavior Change Support Framework Using Gamification for Individuals at Risk of Heart Disease

Pantea Keikhosrokiani[1*], Shoban Balakirushnan[2]

[1]Deparment of Computer Sciences, Universiti Sains Malaysia, Minden, Penang, Malaysia; [2]Department of Cardiology, Lincoln University College, Kota Bharu, Malaysia

ABSTRACT

Objective: This study aims to develop a behavior change framework that uses the elements of gamification for individuals who are at risk of heart disease. Furthermore, it tests the effects of the gamification elements introduced on behavior change which is measured using a Readiness to Change questionnaire.

Participants: 35 participants aged above 30 with BMI greater than 25 kgm^{-2} were recruited participated in this study.

Method: Using literature review, a framework is proposed that links the gamification elements to their corresponding strategies of the Transtheoretical Model. This framework leads to behavior change and ultimately a healthy lifestyle as a health outcome. The proposed framework is tested using an intervention study with a repeated measure research design. The participants underwent a four-week intervention period where they were required to measure the number of daily steps and daily caloric intake.

Results: The effect on the health outcome is measured, using BMI, to evaluate the effect of the gamification elements on the behavior change to affect health outcomes. The results of the analysis as well as a feedback discussion with the participants after the intervention were used to further revise the framework.

Conclusion: The proposed framework can be applied to develop gamified mHealth applications and used for gamification-based behavior change framework.

Keywords: mHealth; Heart disease; Behavior change; Gamification; Readiness to change

INTRODUCTION

Cardiovascular Disease (CVD) is the highest cause of death globally (WHO 2019). The high mortality rates of CVD are becoming more prevalent in developing nations especially in our country. The rising levels of average Malaysian Body Mass Index (BMI) contribute the rise of more overweight and obese individuals in the population. This tide of people suffering from excessive weight puts them at risk of CVD [1]. The impact of CVD thus can be overcome by weight loss techniques, the most effective of which are physical activity and having a healthy diet, genetic factors notwithstanding. These healthy changes to lifestyle need to be made by those at risk in order to prevent CVD. The current trend of health-based applications, more specifically lifestyle modification based were found to have persuasive features leaning towards self-monitoring, social comparisons and suggestions as reported by [2]. Gamification through mobile health applications is a viable conduit for causing behavior change towards achieving a healthy lifestyle [3]. Therefore, this study plays a significant role to determine whether a successful behavior modification technique through the gamification can be formulated.

This study employs the use of gamification elements in producing an intervention that promotes behavior change towards a healthier outcome to reduce the risk factors of heart disease. This study will focus on both diet and physical activity within the health domain of behaviour change. This is due to a lack of gamification-based combination lifestyle behaviour change interventions as most studies focus on a single lifestyle change [4]. Apart from that, most disease management studies are focused on either younger individuals or individuals affected by disease [5]. There is gap for studying the impact of gamification on individuals at risk of CVD due to age factors.

These reasons make this study essential in pursuing the framework.

MATERIALS AND METHODS

Research design

The proposed design of this study is a mixture of quantitative and qualitative study that looks to identify key factors of a habit change support framework and design that framework as well as evaluate the framework. The recruitment process was conducted using convenience sampling and successfully got 35 participants for the study. The proposed study will use qualitative study to improve and work on the behavior change application framework through participant feedback. The quantitative aspect will focus on the evaluation of the framework.

The quantitative study is of the repeated measure study design. In this design, the participants will undergo evaluation for their readiness to change their behaviors and weight measurements prior to and after gamification elements are being introduced to their intervention. The data collected will be analyzed using descriptive and the specific objectives be achieved through Repeated Measure Analysis of Variance (ANOVA).

Study flow

This study begins when literature review is conducted. A study into the topics of gamification and behavior modification. This literature review is essential for the formation of an initial or hypothetical framework design. To test the design, the intervention test is done to evaluate the initial framework. For the purpose of running the tests, participants are recruited and ensured that they fit the wanted criteria as well as filter out those who are in violation of it. This is being done while selecting the participants or when their initial or baseline measurements are made. The measurements in this study that are collected are demographics, body mass index (BMI) and readiness to change (R2C), done through questionnaires.

Next is running the intervention. The first two weeks of the study are run without any gamification elements introduced. This is done to ensure a control. The following two weeks, gamification elements are introduced. Therefore, the measurements are done before the intervention as an initial point, at the end of the first two weeks signaling the end of control and finally at the end of the study to measure the end of the experiment. The reasoning behind the three points of measure is to identify a change in BMI and R2C between them. After the intervention, group interview sessions were conducted to identify the feedback from the participants. This feedback is to provide the participants with clarity of their intervention process as well collecting valuable comments and remarks that may or may not inflict a significant impact on the final framework. This entire process until the formation of the final framework plays an integral role in the framework itself and therefore a part of the final framework with the results justifying the success of gamification to induce change in BMI and R2C. Figure 1 illustrates the flow of this study.
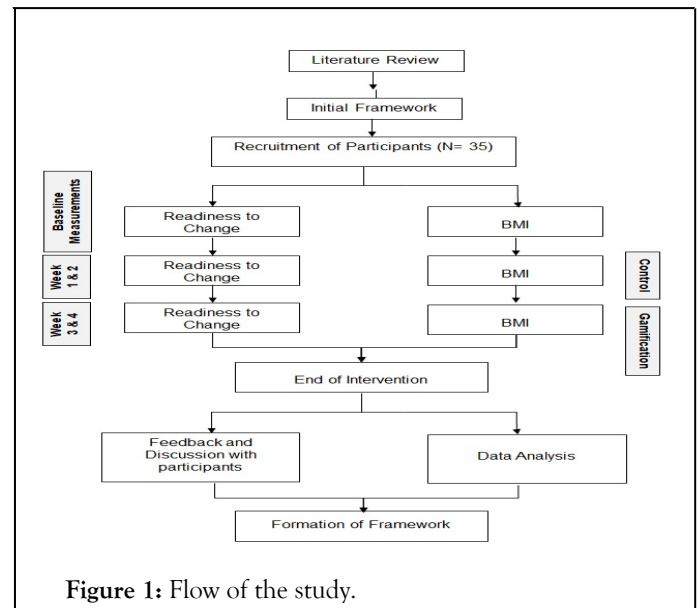

Figure 1: Flow of the study.

Sampling

For this study, convenience sampling is used to recruit participants required. The study population for this study looks at the population of Kedah, Malaysia. The calculations for sample size were done using G*Power sample size calculator [6]. The calculations were found to require 31 participants for the study. The number that was recruited includes a ten percent failure rate therefore the appropriate sample size used for this study was 35 participants.

Selection criteria

Inclusion criteria are individuals above 30 with a body mass index that classifies them as overweight or obese. Participants are chosen using age because the risks of cardiovascular disease increase with age while BMI is known to be a factor for CVD [7]. In this study, participants that are selected should be at risk of heart disease and not in any immediate danger of being hurt by the study. Therefore, any individuals affected by critical illnesses, mental illnesses and pregnant will be excluded. They must not be involved in any ongoing diet or exercise intervention.

Study apparatus

For the quantitative element of this study, a questionnaire and two on the market health mobile applications are used to measure participants' level of physical activity and dietary intake. The questionnaire being used is known as the Readiness to Change Questionnaire. Participants' weights are self-reported.

The readiness to change questionnaire

This questionnaire is used to assess the readiness to change of the participants of the study. The questionnaire being used in this study is a modification of the questionnaire design [8]. The design of the questionnaire is based upon several important criteria that allow for the staging of the intention to change to be measured in greater detail.

Questionnaire design

The questionnaire is designed to have three main parts. The first is the demographics of the participant followed by the weight as well as the height of the participants. The final section which measures the participants readiness to change, consist of two questions that require the participants to report the current stages of their readiness for exercise as well as diet. The demographics section consists of age, gender, and race and education level. These are recorded to understand the distribution of participants who have been recruited for the study. Therefore, the demographics of the study are vital to understand the sample population that is to be tested.

Intervention design

The intervention in this study comprises of daily walking and calorific control of participants diet. No vigorous training will be needed. The walking counter will measure the amount of steps taken in a day and participants will only need to keep score of them. For the dietary intake, participants are required to eat within average calorific daily requirements where it is 2500 k/Cal per day for men and 2000 k/Cal per day for women. Participants are required to stay within the safe levels of their daily calorific intake and should not fall below 1500 k/Cal for women and 2000 k/Cal for men.

Physical activity and dietary intake measurements

In order to measure daily physical activities, a pedometer application found in the app store will be used, Pedometer-Step Counter Free & Calorie Burner while Calorie Counter by Fatsecret will be used to measure participants daily calorific intake. Figure 2 shows the user interface for the Pedometer-Step Counter Free & Calorie Burner while Figure 3 shows the user interface for Calorie Counter by Fatsecret.

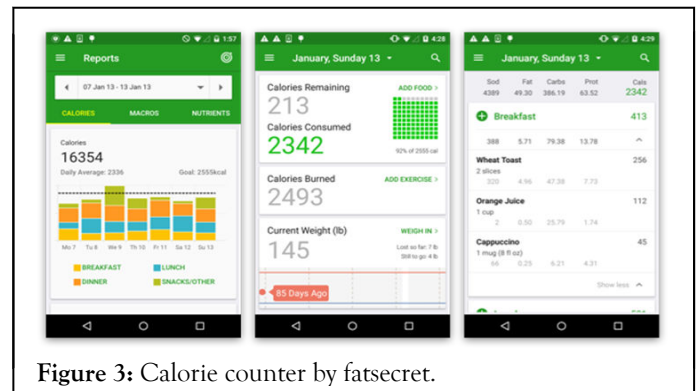**Figure 2:** Pedometer-step counter free.

Figure 3: Calorie counter by fatsecret.

Gamification of the intervention

The gamification aspects in this study will be implemented through these measurements. Firstly, for the pedometer, each 100 steps taken will award a single point to the participant with a minimum of 1000 steps already done. For the calorific counter, the maintenance of the average calorific level will award a single point and for every 100 calories below the average that the participant goes, the participants gain an extra 1 point. However, no points will be given if participant goes above average or below the safe levels of their respective average levels. Apart from the points given, there are daily leaderboards posted in social media for the participants. These leaderboards will be updated daily after self- reporting and at the end of the week, top 10 participants will be showcased. The leaderboards will be posted in the Facebook group page for this study as well as a WhatsApp messenger group that allows for the discourse of the participants within the group.

RESULTS AND DISCUSSION

Prospective studies such as designed their gaming based intervention using similar principles that our study has tested. Among the elements or strategies that they have included are feedback, reward and punishment as well as self-monitoring aspects. This similarity invokes a common overarching modelover the subdomain of chronic disease management as their study focuses on patients with cardiovascular disease.

This study achieves its objective in developing a framework for behaviour change using gamification as an intervention for the target population of individuals at risk of heart disease. The framework was formed using an intervention study that measure the effects of gamification on behaviour change as well as its impact on the health outcome.The findings have yielded a successful framework that encompasses an entire process of developing a framework from the initial stage of literature findings to testing the relationships within the framework of the study.The results of the quantitative study gave us a strong indication of the effect of gamification towards diet and physical activity behaviour change. This confirmed our first specific objective to evaluate the effect of gamification elements towards behaviour change. The qualitative study strengthened this by determining the impact of each gamification element with the participants rating the points as the highest followed by the feedback and progress elements.

CONCLUSION

On the other hand, the health outcome was proven to have non-significant changes from the intervention. This finding is a ground for further tests and improvements in the study design. Nevertheless, the outcome still satisfies the second specific objective by determining that the behaviour change did not affect the BMI change of the participants significantly. Inconclusion, this study managed to achieve the research objectives by conducting the intervention and forming a framework successfully.

REFERENCES

1. Mozaffarian D, Wilson PW, Kannel WB. Beyond established and novel risk factors: Lifestyle risk factors for cardiovascular disease. Circulation. 2008;117(23):3031-3038.

2. Matthews J, Win KT, Oinas-Kukkonen H, Freeman M. Persuasive technology in mobile applications promoting physical activity: A systematic review. J Med Syst. 2016;40(3):1-3.

3. Cotton V, Patel MS. Gamification use and design in popular health and fitness mobile applications. Am J Health Promot. 2019;33(3): 448-451.

4. Eysenbach G. The law of attrition. J Med Internet Res. 2005;7(1):e402.

5. McKay FH, Cheng C, Wright A, Shill J, Stephens H, Uccellini M. Evaluating mobile phone applications for health behaviour change: A systematic review. J Telemed Telecare. 2018;24(1):22-30.

6. Neubeck L, Lowres N, Benjamin EJ, Freedman SB, Coorey G, Redfern J. The mobile revolution—using smartphone apps to prevent cardiovascular disease. Nat Rev Cardiol. 2015;12(6):350-360.

7. Johnson D, Deterding S, Kuhn KA, Staneva A, Stoyanov S, Hides L. Gamification for health and wellbeing: A systematic review of the literature. Internet Interv. 2016;6:89-106.

8. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. Behav Res Methods. 2009;41(4):1149-1160.