

# WiseBP: Mobile Application For Blood Pressure Monitoring

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**Abstract:** The prevalence of hypertension in Malaysia is increasing. Hence, awareness and control of hypertension is necessary. Generally, hypertension patients need to check-up regularly to keep track for their health care including blood pressure. However, doctor might not be able to always keep track on them and give them immediate feedback. Therefore, it can be helpful in diagnosing or monitoring high blood pressure if they record their readings in a blood pressure log electronically. WiseBP mobile application that let users to record blood pressure reading and the data is saved inside the application. They can view blood pressure chart to know which blood pressure categories they are. There are also reminder features and diet and exercise suggestions provided in this application. This mobile application is developed using Android Studio software and the methodology chosen for this project is Multimedia Mobile Content Development (MMCD). In short, WiseBP application is an Android based health self-monitoring application for hypertension patients to monitor their blood pressure with improved features to assist patients in self-managing their lifestyle.

**Keywords:** Hypertension, monitoring, mobile application

## 1. Introduction

Undeniably, high blood pressure, can also be called as hypertension is a crucial medical and public health issue. As one ages, hypertension turns out to be practically inevitable. The prevalence of hypertension increases with propelling age to the point of being 50 % in people from 60 to 69 years old and around 75 % in those 70 years old and older [1]. Hypertension contributes to the burden of various diseases including heart disease and it leads to premature mortality and morbidity. In fact, for people who were non-hypertensive at 55 or 65 years individually the lifetime risk of developing hypertension is approximately 90 %. Globally, 1 in 5 adults has hypertension, and 12.8% of total deaths worldwide are caused by high blood pressure [2].

The health application market is developing a great amount of new health applications are published every year. According to research, approximately 100,000 new health-related mobile applications were published in 2016, resulting in a total of 259,000 health applications currently available in the major

app stores. The download rate of health applications reached 3.2 billion in 2016, which indicate an increase of 7% compared to 2015[3]. Using a mobile application for self-management purposes could make controlling blood pressure simpler for patients with high blood pressure. These applications may have features like diary to promote logging of blood pressure measurements in an organized way, while reminder functions could facilitate monitoring and medication adherence. Moreover, health applications may provide valuable background information for patients about the disease such as its treatment, how to measure blood pressure sufficiently, and lifestyle management. Analysis tools for example graphs and trend analysis may provide an overview of the course of blood pressure over time.

Patients with high blood pressure need to visit their doctor regularly for a check-up and keep track for their health care including blood pressure. However, doctor might not be able to always keep track on them and give them immediate feedback. Hence, it can be helpful in diagnosing or monitoring high blood pressure if patients record their readings in a blood pressure log electronically. This gives you the option of sharing your data with your health care providers and family members.

Thus, this application is an alternative tool for hypertension patients to self-monitor their blood pressure and hopefully help to reduce risk of developing other serious disease. This project is developed to fulfil three objectives: (i) designing the content of a mobile application for self-monitoring of users' blood pressure; (ii) developing the WiseBP application on Android platform; (iii) performing functional testing on developed application. The application consists of six modules: profile, record blood pressure, records, blood pressure chart, reminder and diet and exercise. The target user for this application is patients with high blood pressure. This mobile application is developed in English.

## 2. Literature Review

Hypertension is usually considered as “silent killer” because there are no symptoms. Many people do not know that they have high blood pressure until they have problems with their heart, kidney, or brain. The common factor that causes hypertension is smoking, being overweight or obese, lack of physical activity, too much alcohol consumption, too much salt in the diet, stress, old age, genetics and so on [4]. The risk of getting high blood pressure can be lowered with a healthy lifestyle. Besides, patients have to cooperate with their doctors to achieve good blood pressure control by knowing their blood pressure. Hence, monitoring blood pressure regularly and keeping a record to share with the doctor is a highly recommended action.

Suboptimal blood pressure management is estimated by the World Health Organization to be the leading risk factor for death [5]. Based on the study conducted in all states of Malaysia, the overall prevalence of hypertension for subjects aged 15 years old and above was 27.8%. The prevalence of hypertension was significantly higher in males (29.6%) compared with females (26.0%). Only 34.6% of the subjects with hypertension were aware of their hypertensive status, and 32.4% taking anti-hypertensive medication [6]. From this statistic we can conclude that in Malaysia, the predominance of hypertension is high, but the levels of awareness, treatment and control are low.

### 2.1 Mobile Application for Healthcare

Health applications are application that provide health-related services for smartphones. The use of mobile devices to monitor the health or location of patients with chronic diseases has already become an applicable option. Mobile device applications can offer public health surveillance, help in collecting community data, or assist disabled persons for living. Health care applications is very popular in the market on the consumer side. In fact, 71% of patients said they would prefer doctors to use the healthcare mobile application. Another research found out that 70% of medical school students reported using at least one medical app regularly, with 50% using their favorite app daily [7]. Hence, we can see that the use of medical apps has become demanding and common.

Smart BP [8] is an example of a simple blood pressure app, available for iPhone and Android. The main interface of the application shows the blood pressure entry screen that enable users to record blood pressure readings and save. Additionally, there is a reminders button on the top left which takes user to their device’s reminder app. There are also history and chart which let users view records and visualize the chart over a period. In terms of HCI, the application interfaces convey a clean and tidy feel to user. All the information is well-arranged on the screen. However, for the chart part some of the users may find line graph more difficult to comprehend than bar chart or pie chart.

Blood Pressure Checker Diary [9] is another application that is designed to keep the complete track record of the user’s blood pressure. The application will specify whether the blood pressure recorded by users is normal, high or low in the history page. However, this application lacks some important features. It cannot generate blood pressure graph, no reminder features and profile module provided. Besides, the reading user saved cannot be updated and delete. Moreover, the design of the user interface is quite simple and less attractive compared to other applications.

BP Journal – Blood Pressure Diary [10] application let users to log blood pressure readings, view charts, and send reports to their personal physician. It enables users to monitor blood pressure trends with statistics and interactive pie charts. The results of blood pressure can also be generated in PDF form. User can also set up reminders to take blood pressure measurements. Nonetheless, it also does not contain diet and exercise module. This application has good design and user-friendly navigation. With all-rounded features and nice user interface which provides good user experience it is a good choice for blood pressure self-monitoring application.

Based on review of existing application, WiseBP consists of six modules: profile, record BP, records, reminder, chart, diet and exercise. In the profile module, user have to enter some basic details. All user data will save inside profile and user is able to edit it. The main modules are the record BP and records module which let user record blood pressure readings and manage their data. Users can view, search, update and delete the data in Records module. The fourth module is BP Chart which generate blood pressure chart. Furthermore, reminder module is provided for users to remind them for blood pressure measurement on time. The last module will be the diet and exercise module which include the recommended meal and exercise for hypertension patients.

### 3. Methodology

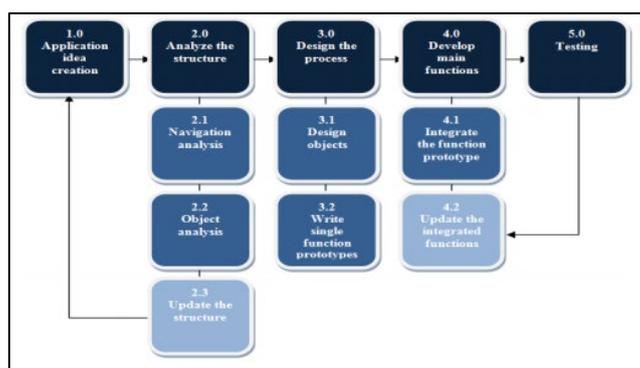


Figure 1: Multimedia Mobile Content Development (MMCD)

WiseBP mobile application is developed using Multimedia Mobile Content Development (MMCD). This selection is made because it can make the development process simpler and reduce the occurrence of potential problems during development. It has been proven to speed up the application development process and optimizing the mobile processing and data usage at the same time [11]. MMCD model consists of five main phases which is application idea creation, analyze the structure, design the process, and develop main function and testing.

### 3.1 Application Idea Creation Phase

Application Idea Creation Phase is the phase where the developer prepares the information needed before the design and development of the application start. The application idea creation checklist produced in this phase is shown in Table 1.

**Table 1: Application Idea Creation Check List**

Item	Note
Type of Application	Companion application for blood pressure recording
Target device	Smartphone with Android Version 5.0 Lollipop and above
Target users	Hypertension patients
Images	Module icons, suggested meal and exercise images
Audios	None
Videos	None
Application synopsis	WiseBP application is an Android based health self-monitoring application for hypertension patients to monitor their blood pressure with improved features to assist patients in self-managing their lifestyle. Patients with high blood pressure need to visit doctor regularly for check-up and keep track for their health care including blood pressure. However, doctor might not be able to always keep track on them and give them immediate feedback. Hence, it can be helpful in diagnosing or monitoring high blood pressure if you record your readings in a blood pressure log electronically.

### 3.2 Analyze the structure

The next phase is structure analysis phase. Two sub-components were analyzed in this phase which is navigation analysis and object analysis of the application. Navigation analysis is to design the structure flow of the application to provide excellent user experiences. The flow of process for each module in the application is analysed in this phase. These activities need to be carried out to give a visual overview of the application. These visual representatives are an alternative to make people understand better about the flow and navigation of the application.

Object analysis determines the user interface and interaction buttons that involved in this application. User interface design is important to promote the interactions between user and the application. In order to accomplish this purpose, concept of human-computer interaction is applied in designing a user interface that is simple, easy to understand and can provide usability to the target users. In the aspect of buttons, all the buttons and icons designed should not be too small but need to be clear and noticeable as majority of the target users will be elderly. If there are any changes made, the result from any two of this analysis will be updated. Table 2 shows the application structure checklist based on the application idea creation phase.

**Table 2: Content Structure Checklist**

Item	Note
Layout Design	<ul style="list-style-type: none"> <li>• Screen 1: Splash screen</li> <li>• Screen 2: Register page</li> <li>• Screen 3: Login Page</li> <li>• Screen 4: Main interface</li> </ul>

**Table 2: Content Structure Checklist (cont.)**

Item	Note
	<ul style="list-style-type: none"> <li>• Screen 5: Profile interface</li> <li>• Screen 6: Record BP interface</li> <li>• Screen 7: Records interface</li> <li>• Screen 8: BP Chart interface</li> <li>• Screen 9: Reminder interface</li> </ul>
Menu and navigation	Screen 10: Diet & exercise interface
Number of GUI	Grid form to separate each module
	<ul style="list-style-type: none"> <li>• Application logo</li> <li>• Module icons</li> </ul>
Images	Images of recommended meal and exercise in diet & exercise module
Placing audio	None
Placing video	None
Storyboard	As shown in Appendix A

### 3.3 Designing the Process

The main objective of this phase is to design a complete architecture of the application. In this phase, user interface and buttons are designed by using the output from previous phase. The activities involved in the design phase are designing the flowchart, storyboard and database that is used in the development of the application. The storyboard designed in this phase will visualize the function and features of the application to give a better vision and understanding towards the application. Database design is also vital for this application as it needs detailed data model to store the data. The entities and attributes of the data as well as the metadata of each entities such as data type, data size and primary key for the application are determined during this phase. Database implementation was done using Firebase and SQLite.

This stage consists of two sub-components that is designing objects and writing script for single function prototype. All of the graphical objects were downloaded from free source websites and are further modified in Adobe Photoshop CS6 and Adobe Illustrator CS6. The objects are then copied to the resource folder in Android Studio. Next, *Extensible Markup Language (XML)* is used to design and place the graphics to each interface at the layout page. The prototype has to be done at the end of this process to view the overall form of the project. Function prototypes and scripting were developed using Java programming language and Extensible Markup Language (XML) in Android Studio. Figure 2 shows the code snippet for performing the blood pressure recording function

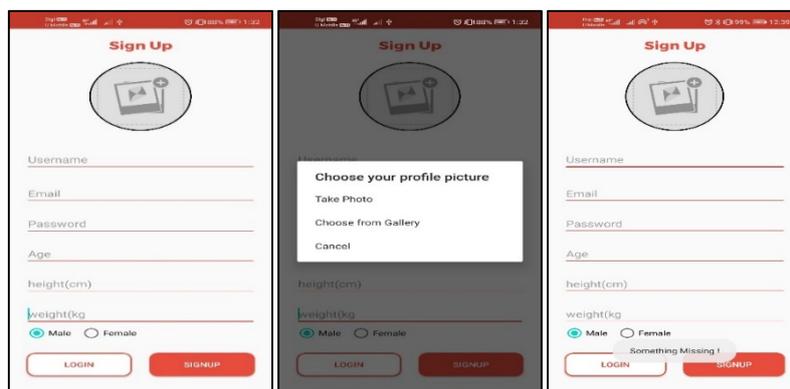
```

sqlite=new SQLite( this );
save.setOnClickListener( new View.OnClickListener() {
    @Override
    public void onClick(View v) {
        calculateBtn();
        DateFormatdateFormat = new SimpleDateFormat("dd/MM/yyyy");
        Date date = new Date();
        String DATE= String.valueOf(dateFormat.format(date));
        SQLiteDatabase database = sqlite.getWritableDatabase();
        ContentValues values = new ContentValues();
        values.put("top",stop);
        values.put( "bottom",sbottom );
        values.put( "date",DATE );
        values.put( "pulse",spulse );
        database.insert("bp", null, values);
        database.close();
        Toast.makeText(CalculateBpActivity.this, "Saved !", Toast.LENGTH_SHORT ).show();
    }
});
values.put("top",stop);
values.put( "bottom",sbottom );
values.put( "date",DATE );
values.put( "pulse",spulse );
database.insert("bp", null, values);
database.close();
Toast.makeText(CalculateBpActivity.this, "Saved !", Toast.LENGTH_SHORT ).show();
}
});
    
```

**Figure 2: Code snippet for performing blood pressure recording**

### 3.4 Developing the main function

This phase is important as it is the part of the project that consume most of the time and it is highly challenging. During this phase, the design model that was created earlier is translated into coding by using the previously identified programming language and software tools. This phase integrates the function of the module and button in the application. The prototype was integrated in confirming the usability and functionality of the application and also on updating the function for each button and module involved. Also, mobile operating system emulator is used in order to test the result of the coding in Android Studio. Figures 3 –5 shows several screenshots of the application interface.



**Figure 3: Register interfaces**



Figure 4: Profile interfaces

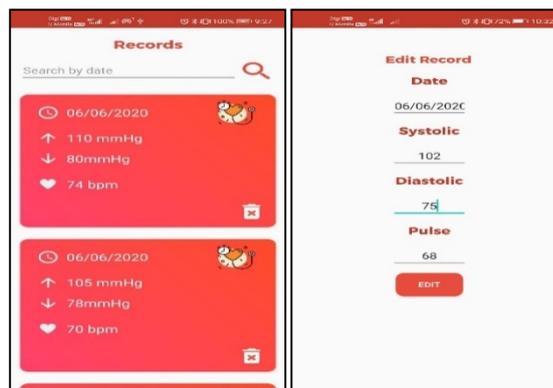


Figure 5: Records interface

#### 4. Results and Discussion

It is important to ensure that the application fulfil the requirement and functions properly. Therefore, functional testing is carried out to ensure that each module functions according to expected output under certain given condition. A total of eight test plans were carried out to test the functions of WiseBP application. Table 3 shows the result of the application’s test plan.

Table 3: Results of functional testing for WiseBP application

Modules	Test	Expected result	Output result
Login	Complete with valid username and password	Login successful into the application	Pass
	Incomplete data inputs	Login failed and prompt users to complete the details	Pass
	Complete but invalid username or password	Login failed with failure message displayed	Pass
Register	Complete with valid user registration data	Registration successful and login to the application	Pass
	Incomplete data inputs	Login failed and prompt users to complete the details	Pass
	Register using existing username	Failure message displayed and prompt users to create another username	Pass
Profile	Check whether the user details successfully display without error	Display the complete details successfully	Pass
	Update the detail of user	User’s detail successfully updated	Pass
	Sign out account	Sign out successfully and login page is displayed	Pass
Recording Blood Pressure	Add new blood pressure reading	New record is added to the application	Pass
	Add incomplete blood pressure reading	Record not saved	Pass
Records	Add new blood pressure reading	New record is displayed on the records screen	Pass

**Table 3: Results of functional testing for WiseBP application (cont.)**

Modules	Test	Expected Result	Output Result
Records	Delete particular data	Data deleted and remove from the database	Pass
	Search data by date	The matched data is displayed	Pass
	Search data by invalid date or by date that does not exists in database	No 'data' message appeared	Pass
	Edit the data	Data edited and updated data is displayed	Pass
Blood Pressure Chart	Record a blood pressure reading	The chart is generated based on the data entered on the correct blood pressure category with correct percentages	Pass
Reminder	Set a reminder	The time set is displayed on screen and notification popped out at notification section of phone when the time reach	Pass
	Cancel reminder	The reminder cancelled successfully	Pass

**5. Conclusion**

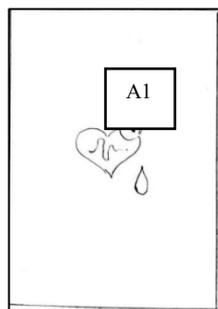
In conclusion, WiseBP application has achieved the objectives which is to design the content of a mobile application for self-monitoring of users' blood pressure and to develop a mobile application using Android platform for blood pressure monitoring. However, there are improvements that can be done by enhancing the functionalities and performance of the application. Firstly, the application can be developed in cross-platform so that not only Android OS mobile phone can use this application. Second, it is recommended that the blood pressure chart generated can view more recent and categorized results such as weekly, monthly and yearly instead of including all the data. This can let users know their recent blood pressure category. Lastly, it is better if the reminder feature can have the repeat option instead of one-time basis.

**Acknowledgement**

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**Appendix A**

Storyboard of the application are as follows.

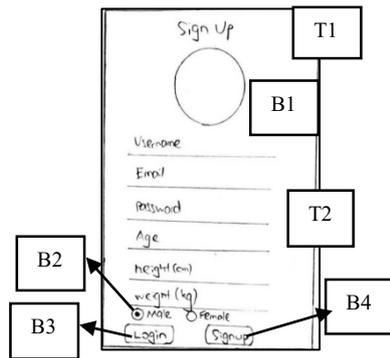


**FigureA:**

This is the first screen that will be displayed when launching the app. An animation will displayed on the screen.

Element	Behaviour
AI	Animation icon

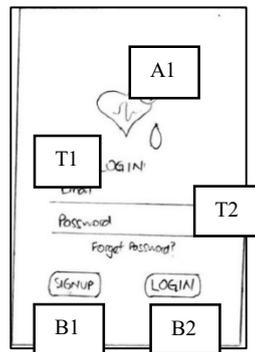
**Splash Screen**



This screen is Sign Up page for user that don't have an account to create new account by filling up all the information before proceeding to the main interface.

Element	Behaviour
T1	Name of the page
B1	Image button to to input profile picture
T2	Text field to input sign up information
B2	Radio Buttons to choose gender
B3	Login button
B4	Sign up button

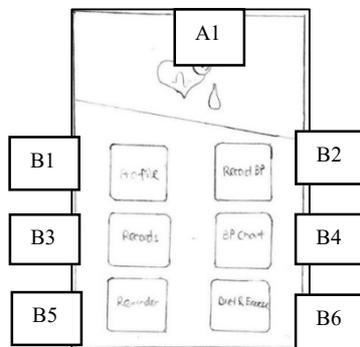
Figure B: Sign Up Page



This screen is the Login screen which will be displayed after the splash screen. Users have to enter their email and password to login.

Element	Behaviour
A1	Animation icon
T1	Name of the page
T2	Text field to input email and password
B1	Button to sign up
B2	Button to log in

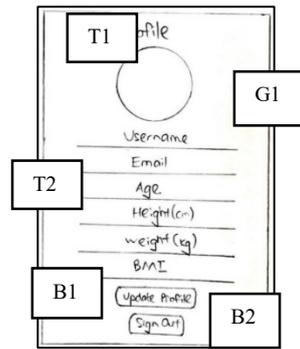
Figure C: Login Page



This is the main interface of WiseBP app. It contains six image buttons in cardview which is Profile, Record BP, Records, BP Chart, Reminder and Diet/Exercise module. The logo of the app on the top will animate.

Element	Behaviour
A1	Animation on application logo
B1	Image button to Profile module
B2	Image button to Record BP module
B3	Image button to Records module
B4	Image button to BP Chart module
B5	Image Button to Reminder module
B6	Image Button to Diet & Exercise module

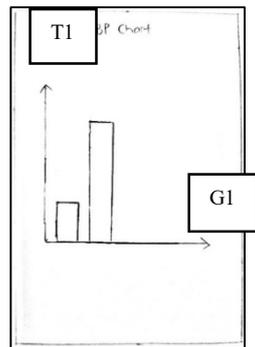
FigureD: Main interface



This is the profile screen which displays all the information about users with a circular profile photo which the app prompt the user to do so in Sign Up page. All the data can be edited except email.

Element	Behaviour
T1	Name of the page
G1	Profile image
T2	Text fields displaying user's details
B1	Button to update profile
B2	Button to sign out

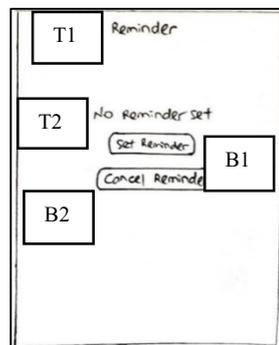
Figure E: Profile page



This is the BP chart interface of WiseBP. It generates bar chart based on user's blood pressure reading recorded and indicates user the blood pressure category they belong to.

Element	Behaviour
T1	Name of the page
G1	Chart showing user's blood pressure category

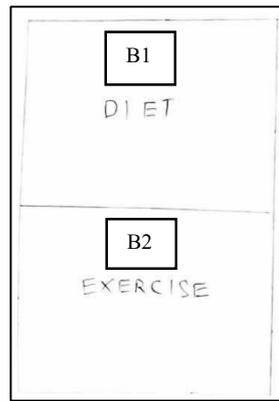
Figure F: BP Chart page



This is the reminder screen. Whenever user set a reminder through 'set reminder' button, the text view will change to the reminder time they set. User can cancel the reminder by clicking on 'Cancel Reminder'.

Element	Behaviour
T1	Name of the page
T2	Text showing reminder status
B1	Set reminder button
B2	Cancel reminder button

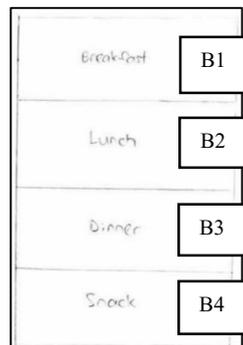
Figure G: Reminder page



This is the interface of diet and exercise module. User will proceed to the diet interface and exercise interface respectively by clicking on the diet and exercise image button.

Element	Behaviour
B1	Image button to navigate to diet module
B2	Image button to navigate to exercise module

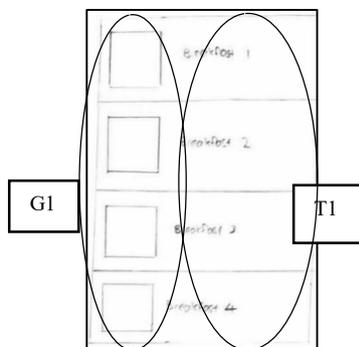
**Figure H: Diet & Exercise page**



This is the interface of diet module. User will proceed to breakfast, lunch, dinner, and snack category by clicking on breakfast, lunch, dinner and snack image button respectively.

Element	Behaviour
B1	Image button navigates to breakfast page
B2	Image button navigates to lunch page
B3	Image button navigates to dinner page
B4	Image button navigates to snack page

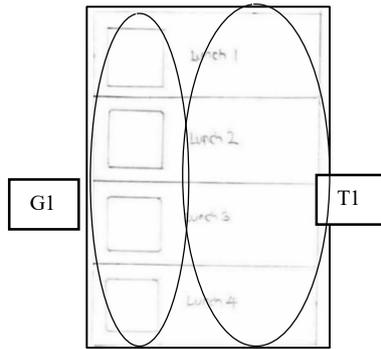
**Figure I: Diet page**



This is the interface of breakfast page. All the recommended breakfast images are displayed with name of the food.

Element	Behaviour
G1	Suggested breakfast's images
T1	Suggested breakfast's name

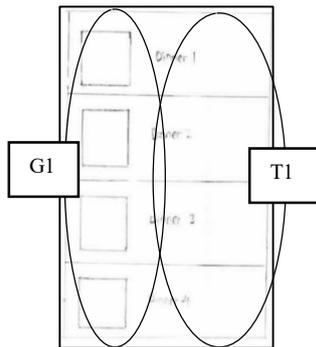
**Figure J: Breakfast page**



This is the interface for lunch page. All the recommended lunch images are displayed with name of the food.

Element	Behaviour
G1	Suggested lunch's images
T1	Suggested lunch's name

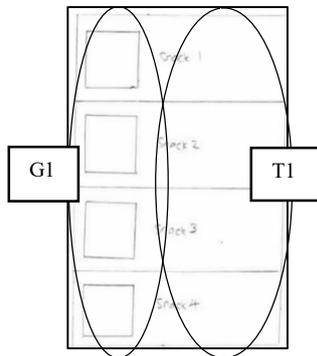
**Figure K: Lunch page**



This is the interface of dinner page. All the recommended dinner images are displayed with name of the food.

Element	Behaviour
G1	Suggested dinner's images
T1	Suggested dinner's name

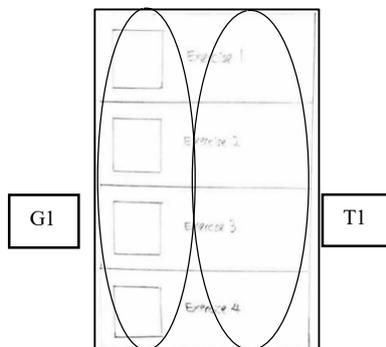
**Figure L: Dinner page**



This is the interface of snack page. All the recommended snack images are displayed with name of the food.

Element	Behaviour
G1	Suggested dinner's images
T1	Suggested dinner's name

**Figure M: Snack page**



This is the interface of exercise page. All the recommended exercises images with name are displayed at here.

Element	Behaviour
G1	Suggested exercise's images
T1	Suggested exercise's name

**Figure N: Exercise page**

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