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YORwalK: Desiging a Smartphone Exercise Application for People with Intermittent Claudication

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Abstract. Peripheral Arterial Disease (PAD) is a chronic cardiovascular disease. It is highly prevalent in older adults. Mobile Health (mHealth) and Telehealth technologies are considered two central digital solutions for enabling patient-centred care. There is evidence that physical activity apps can improve health outcomes in adults. The aim of this project is to develop a prototype of smart phone app to target patients with PAD, which we named YORwalK, to promote exercise and track changes in walking ability in this population. We used a multidisciplinary team combined with a User Centred Design approach. We performed an evaluation survey using modified System Usability Scale (SUS). The survey was to assess the usability of the App and completed by health care professionals. The App was developed based on the concept of promoting behaviour change through feedback and life style prompts. YORwalK features incorporate self-monitoring and motivating feedback. SUS result indicating higher usability of the App.

Keywords. Peripheral Arterial Disease, Intermittent Claudication, Mobile Application.

Introduction

Peripheral Arterial Disease (PAD) is a chronic cardiovascular disease characterised by atherosclerotic narrowing or occlusion of the arteries supplying the legs. It is highly prevalent in older adults, affecting around 20% of adults aged > 70 years [1, 2]. Around 10% to 35% of patients report the typical symptoms of intermittent claudication, which is specifically defined as lower-limb discomfort or pain on exertion that is relieved within 10 minutes of rest; however, a further 30% to 40% report other, atypical lower-limb symptoms [3]. Intermittent claudication impairs quality of life by limiting ambulation and activities of daily living [4].

Supervised exercise training, particularly that which involves walking as the main exercise modality, is an effective treatment for improving walking ability in individuals with intermittent claudication [5]; however, only few supervised exercise programs exist specifically for these patients [6], limiting access to this therapy. As such, most patients with intermittent claudication are unable to participate in supervised exercise. For unsupervised exercise programs, the evidence is currently weak and mixed [7]. In particular, a lack of sufficient motivation and pain has been cited as major barriers to participation in self-managed exercise [8].

Mobile Health (mHealth) and Telehealth technologies are considered two central digital solutions for enabling patient-centred care [9]. By offering timely, personalised and interactive access to health data and services, a primary aim is to empower patients to take a more engaged role in their care process and improve the quality of the coordination of care between patients and carers. In particular, the number of mHealth apps that support self-management and self-monitoring has increased significantly. It was estimated that, by 2017, 65% of these apps will focus on capturing and communicating data to measure patient conditions, with emphasis on managing chronic diseases [9].

Claims concerning the benefits of these digital technologies have to be supported by the necessary evidence of efficacy, cost-effectiveness, usability, safety and security. In terms of efficacy, the systematic review of Schoeppe et al. provided modest evidence from 13 studies that physical activity apps can improve health outcomes in adults, with efficacious interventions including goal-setting, self-monitoring and performance feedback in the app design [10]. However, none of the studies in this review included people with intermittent claudication or mHealth apps specific to this population. The aim of this paper is to develop a prototype of such an app, which we named YORwalK, to promote exercise and track changes in walking ability in this population. The app development process and the preliminary evaluation is described herein.

1. Methods

At the initial stage, the user requirement of the project was collected using the User Centred Design approach [11]. A Multidisciplinary Team (MDT) formed of two vascular surgeons, two software engineers and an Exercise and Health Sciences researcher were arranged for regular meetings to formulate the requirements and app specification. The system was implemented using the Android platform with the Android Studio version 2.3.3 which is recommended by Google as an Integrated Development Environment (IDE). The user interface was implemented using the final prototype developed based on the feedback from the MDT of the project. Continuous refactoring and testing was done on the code to ensure that it meets the design, standards and user requirements.

We performed an evaluation survey using modified System Usability Scale (SUS) [12]. The survey was to assess the usability of the App. In this cross sectional survey, we targeted random health care staff in York hospital. It has been performed over a week. All candidates had unstructured interview by one of the development group to explain the specification the app. Each candidate was given at least 10 minutes to use the app and explore its specifications and was asked to complete a modified SUS and to give feedback on aspects of improvements needed on the app.

2. Results

A document containing the list and description of the system requirements specification was submitted to the MDT for review (see Table1 for an example requirement). For the app design, various software engineering best practices, guidelines and standards were used to ensure that the app meets the requirements, ensure that usability is achieved. This includes the NHS Digital's SCCI 0129 [13], the Google's Android User Interface Guidelines [14], and the NHS Digital's Common User Interface Design Guidelines [15]. The following artefacts were produced as part of the design process:

- Use Cases: describing the interactions between the user and the App. A use case diagram was developed using the user requirements specified above.
- System Architecture: Model-View-Presenter (MVP) architecture was used for the system architecture. This architecture is recommended by Google as most of the Android components and libraries were created using the MVP approach.
- Database Architecture: a SQLite Database as the recommended database for Android was used to achieve data persistence.
- Activity Flow Design: The Activity flow shows all the activities of the system and how they interact with each other, modelling the manner in which a user navigates from one screen to the other.
- Class Diagram: It is a detail list of the classes representing the Model component of the project. These classes are part of the business logic and are used to hold data that is fetched from the database as well as the data from the presenter. This includes the user data such as age, height and weight, daily activity and six-minutes walking test classes.
- Flow of Control: describing the sequential flow of data for each process in the App. The diagram details how the data is processed when a condition is true or false.

Customer Requirement Identifier	Software Requirement Identifier	Requirement Description
RQ-001.006		**The system shall provide the ability to automatically monitor user's walking behaviours**
	RQ-001.006.027	The system shall automatically and continuously measure the user's normal walking behaviours.
	RQ-001.006.028	The system shall persist this information daily.
	RQ-001.006.029	The system shall calculate the average number of steps after seven days
	RQ-001.006.030	The system shall set the average number of steps plus 500 steps as the user's initial target.
	RQ-001.006.031	The system shall notify the user of the new target.

Table 1: Subset of Requirements Specification

The delivered system comprises the App in Application Package Kit (APK) format which is the file format that is recognised by the Android Operating System. The App was delivered in the Alpha state and its features and functions satisfy the user requirement. The features of the App delivered are described in detail below:

- Daily Activity: This consists of a step counter sensor, progress bar, a step counter display and a rating bar (Figure 1). The step counter sensor detects when the user makes a step, the progress bar shows the percentage progress based on the user's target, the step counter display shows the total number of steps taken by the user and the rating bar shows the rating percentage based on the user target. The step counter has a delay when displaying the number of steps. This is because the step sensor combines and processes steps together instead of reporting them individually; it returns an aggregated number of steps. The rating bar displays a star for each 20% progress completed of a target.

Figure 1: Countdown

Figure 2: Weekly Report

Figure 3: Monthly Report

- The Six-minute Walking Test: This feature uses the same step sensor in the daily activity feature. The Six-minutes Walking Test comprises the walk test instruction pages, the initial countdown of 3 seconds before starting the walk test, the 6 minutes countdown timer, the pain button, the summary of completed walk test and the report (weekly and monthly). The instruction pages details the procedure of how, when and where to perform the test as well as its objectives. The pain button is provided as an option for the users to indicate when they first experience a leg pain. This helps the App to determine the pain free walking distance. The summary of the walk is displayed at the end of the walk.
- The Report Feature: This feature as shown in Figures 2 and 3 is used to track all the activities (daily activity and Six-minutes walking test) done by the user. The reports are represented in bar graphs and line graphs. The weekly report is displayed in a bar chart while the monthly report is displayed in a line chart. The bar and line graphs allows scrolling to see previous and later reports. The reports can also be viewed in landscape in order to have a bigger and better analysis of the graphs.

Finally, 21 health care professional including nurses and doctors had completed the survey. All health care professional worked on surgical inpatient ward and have experience of working with elderly patients. The SUS methodology was used to calculate the score [12]. The mean score was 83.3 (9.6 SD) indicating higher usability of the App.

3. Discussion and Conclusion

The concept of this app is to promote behaviour change through feedback and lifestyle prompts. This concept is supported by results from meta-analysis which showed interventions to increase physical activity among elderly patients have larger effect when they targeted only activity behaviour, excluded general health education, incorporated self-monitoring, used centre-based exercise, and recommended moderate intensity activity [16]. This contrasts to an app developed by Stanford VascTract [17] which has concentrated on data collection and used as research tool. YORwalK is designed using patient centred concept to achieve its planned goals.

The App is available only for modern android phones and that is a weakness in this version. The App should also be able to connect to wearable fitness devices for more accurate reporting of activity. The SUS score suggests higher usability. However, the survey was completed by health care professionals. The target group of patients should be addressed for evaluation of this App to obtain further feedback. The YORwalK team considers seeking feedback from patients through a patients' forum. Target group feedback should be the next step. The following step should be the second phase of developing the App to cover the weak points identified in the first phase. The App then should be tested through clinical trial to assess usability and proof of concept.

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