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Short Communication

Usage of Mobile Devices to Help People Suffering From Peripheral Arterial Disease Upkeep a Healthy Life

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Abstract

A large group of people, particularly the elderly, are affected by Peripheral Arterial Disease (PAD), which causes a progressively reduction of the person's physical fitness. According to the best treatment practices, the Centro Hospitalar de Trás-os-Montes e Alto Douro (CHTMAD) is running a treatment program based on the execution of supervised exercises, including periodic walks. The key factors to the management of the exercise's progression are the control of the beginning and magnitude of the pain, how often the patients with PAD must stop on their walks, and how much time they must wait for the pain to fade. To support the management of this treatment program we are developing an electronic system, based on mobile devices and a webservice, to help the persons with PAD to control the quality and quantity of their walks. The system is a platform for the PAD patients to register and monitor their status and progressions, and for the health professionals to supervise their patients.

Keywords: Elderly people; Mobile devices; Peripheral arterial disease; Android; Smartwatch; Smartphone; Usability

Introduction

In 2010, it was estimated that 200 million people worldwide suffer from Peripheral Arterial Disease (PAD). From 2000 to 2010, the number of people over 80 years old with PAD increased by 35% (Sampson et al., 2013) [1]. With the ageing of the population worldwide, it is expected that the number of persons with PAD will increase. The main symptom of PAD is "intermittent claudication", which is characterized by a leg pain that occurs during simple ambulation or other more vigorous physical activities and fades after the persons topshis physical activity for a few minutes. The PAD causes blockages of the arteries, which affects the blood flow to the legs. In severe cases, PAD may even lead to amputations, particularly, when there is pain at rest, ischaemic ulceration, or gangrene (Ouriel, 2001) [2]. These individuals show a progressively reduction in their physical fitness. A recommended treatmentfor the persons with PAD is the practice of supervised exercise (Gornik H. & Beckman J., 2005) [3].

A research was conducted by Hiatt et al. (1990) [4] with patients with PAD that performed a supervised exercise program, during one hour per day, three times a week over twelve weeks. The researchers concluded that the patients improved their walking performance, peak exercise capacity and reduced the intermittent claudication.

Currently, it is being developed research work focused on developing methods and technologies to help the health professionals to supervise their patients (Paulino et al., 2017) [5]. In the following paragraphs we present three well documented cases.

The system developed by Särelä et al. (2003) [6] consists mainly in a wearable device and a base station, installed at the user´s home, to monitor the user´s movements. The wearable device collects activity data and sends it to the base station, which can synchronize the data with a dedicated server through a wired public telephone line or send alert messages to a caregiver. The target population of this system is the elderly people. The system has the advantage of making the connection with the patient and the caregiver, but has the drawback of not collecting more physical activity data, eg., the step count.

The study conducted by Merihlatti et al. (2009) [7] comprised the development of a system, composed by wearable and ambient technologies to supervise the personal wellbeing. The data collected includes the step count, blood pressure and heart rate. This system was tested with a group of working-age individuals (between 50 and 60 years old) and with elderly people (over 75 years old), monitoring the users´ health and physical activity at home. Although this system can record several health and physical activity parameters, the collected data must be explicitly sent by the users via email.

The research conducted by Fokkenrood et al. (2015) was based on a validation of an activity monitor, which monitors and stores offline the step count and the type of activity performed by a patient (e.g. sitting, resting, locomotion). It can gather data for a maximum time period of seven days and could be useful to help the PAD health professionals to evaluate the activities performed by their patients. It has a handicap, considering that it is the patients' responsibility to send the collected data to the health professional. In this study the target populations were patients with PAD.

Monitoring an Exercise Program

The Centro Hospitalar de Trás-os-Montes e Alto Douro (CHTMAD), in Vila Real, Portugal, is currently running a program of monitored exercise on which the key factors to the management of the exercise's progression are the control of the beginning and magnitude of the pain, how often the patients with PAD must stop while walking, and how much time they must wait for the pain to fade.

In this work, we present a system that uses mobile devices and a web service with the purpose of helping the individuals with PAD to control the quality and quantity of their walks. The quality of the walks is quantified by measuring the following parameters: pain-free walking time, pain-free walking distance, walking time to pause, walking distance to pause, number of pauses during a walking session, the time they have to pause, pause duration, the maximum walking distance, time for the pain to fade at the end of the walking session, the duration of exercise and the duration of pauses. The patient is encouraged to do a forty minutes' walk, three times a week.

The system's architecture includes one web service, two mobile

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applications for smart phone and smart watch, and a website. Using this system, the individuals can do the prescribed exercise program with more autonomy, without having to go to the Hospital just to be supervised. The data is collected during the walks by the mobile devices and is synchronized with a web service. The health professionals can use the website to monitor and supervise the patients´ exercises.

Methodology and Design

The methodology to develop the system was based on the user-centered design approach, using iteration cycles, including the development of prototypes and meetings between computer science researchers and sports and health researchers. The researchers had the contribution of patients with PAD, in the analysis, design and development stages, participating in interviews for requirements analysis and for prototypes testing. All patients that collaborated in the development of the system were suffering from Intermittent Claudication and PAD on stage II of the Fontaine classification with Ankle-Brachial Index < 0.9 at rest (Hirsch et al., 2006) [8].

The system collects the following data: the magnitude and the date from the occurrence of pain; how much time it is necessary for the pain to fade; the number of times the patient stops on his walk; the number of steps; the patient´s location from GPS; and the duration of the walk. The system provides a feature for the patient to register his pain level during the walk and, if needed, the patient can also send emergency notifications to his predefined contacts, by a one click action on the mobile device.

The system is composed by a smart watch application (operative system Tizen), a smart phone application (operative system Android) and a back-end web service in PHP. The application developed for the smart watch has the main feature of collecting the heart rate from user and synchronize it with the application for smart phone, which has five important features: (1) integrate the application with the S Health application to measure the walked distance; (2)calculate the walked distance from the collection of GPS signals; (3) synchronize data with the smart watch and web service; (4) create a mechanism for the users to notify a predefined contact in case of an emergency, by sending an alert message and their last known location; (5) measure the walking time and save the feedback from other users with PAD about his current pain level. The back-end web service has the main feature to make available the CRUD (Create, Read, Update, Delete) operations over the database, following a REST architecture.

After 4 cycles of development, one functional prototype of the system was implemented and usability tests were created to evaluate if the functional prototype was usable. In Figure 1, it is shown the functional prototype graphic interface for the smart watch application.

The elaboration of usability tests allows the collection of the users' opinions and together with the observations, collected during the tests; it is possible to infer if the system is usable. During the usability tests the user registers some walk´s characteristics, previously defined, e.g., the pain magnitude or the duration of the walk. The variables to collect will be, the number of clicks in the application, the type of reactions from the user (positive or negative), and the number of times that the user asks for help. The methods for the data collection are observation, questionnaires, and interviews. The users' test group will be made of patients with PAD.

Conclusion

In this work, and at the current development stage, we have implemented a full working system dedicated to remotely monitor the execution of an exercise program as prescribed to PAD patients. The requirements analysis and design was "user centered" and a very representative group of PAD related users was involved, including health professionals and PAD patients. In the next stages we hope to measure and address the benefits, both for patients and health professionals, of introducing such a system in the patients' therapeutic process.

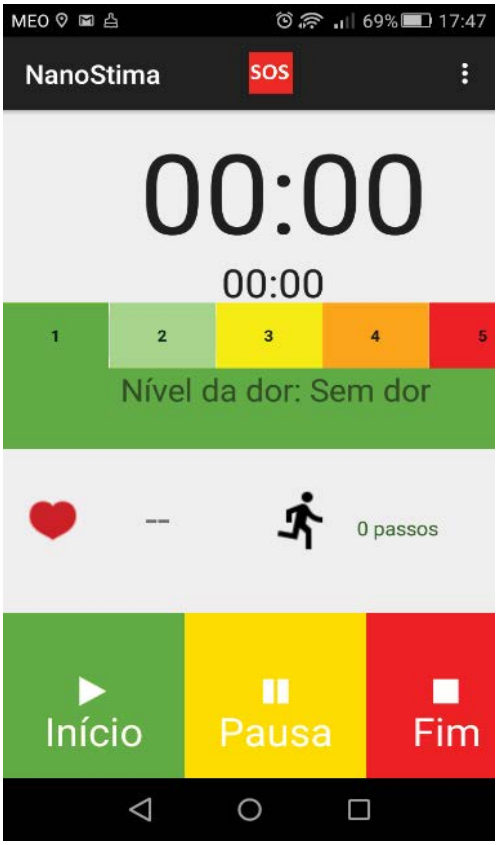

Figure 1: Functional prototype for the smartphone application Translation Portuguese to English: "passos" - "steps"; "Nível de dor: Sem dor"- "Level of pain: Without pain"; Início"- "Start";"Pausa" - "Pause"; "Fim" - "Stop".

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