TWO YEARS OF EXPERIENCE IN IMPLEMENTATION OF THE 'MOBIREH' REMOTE REHABILITATION SYSTEM SUPPORTING PATIENTS AND PHYSIOTHERAPISTS

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Abstract

The aim of this work is to characterise the process of developing the mobiREH telemedical rehabilitation system which was created as a result of cooperation between the mReh start-up team and the scientific team from the Academy of Physical Education in Kraków. The most significant global and local challenges for rehabilitative health services are: the increasing number of patients awaiting rehabilitation, the increasing waiting time for rehabilitation, and the decreasing number of medical specialists. A mobiREH rehabilitation system is a system that supports home based rehabilitation and helps resolve these problems. The system consists of (a) a mobile application, (b) wearable sensors for patients, and (c) a web-based platform for medical specialists.

Keywords: mHealth; rehabilitation; remote monitoring; home-based

Introduction

Around 24% of EU citizens are patients with musculoskeletal diseases undergoing long-term treatment and requiring rehabilitation.[1] Musculoskeletal conditions are amongst the five most common chronic diseases for adults.[2] As a result, productivity of workers is decreased; in Germany this means a yearly loss of about 24 billion EUR.

Eurostat estimates the number of practicing physiotherapists in the EU to be about 510, 000.[3] In the USA for every 10,000 people there 5-20 physiotherapists, and in Canada between 5-10.[4] As seen elsewhere, an insufficient number of physiotherapists and medical doctors constitutes one of the main problems for healthcare in the world. As a consequence, the waiting time for rehabilitation services increases significantly. In Poland the average waiting time is 130 days.[5]

This problem, inadequate numbers of healthcare workers, can be partly resolved by introducing telemedical solutions which allow for remote monitoring of patients, direct and fast communication between medical specialists and the patient, and allows for partial translation of the rehabilitation process to the home environment.

The solution

A mobile and web-based solution, the mobiREH platform, was developed to increase safety and availability of rehabilitation services. The system allows for complex care over the patient and increases a patient's motivation for performing exercises. The system assures continuous care by physiotherapists, even when the patient is at home, and provides the physiotherapist with complete medical data from the rehabilitation process. Constant contact with the patient is ensured.

The system consists of a:

Mobile application. This is for patients with an individualised rehabilitation programme, prescribed by a physiotherapist, and is demonstrated in the form of 3D animations with real-time feedback;

Web platform. This is for specialists – an IT tool **w**hich allows for creation of a customised therapy plan, analysing of medical data, and for monitoring of physiotherapy progress;

Wearable monitoring sensors. These monitor joint movements and compare them with the movement patterns in the database.(Figure 1)

Methods

From the beginning mobiREH was built in close collaboration between mReh and other research institutions (e.g. Jagiellonian University Medical

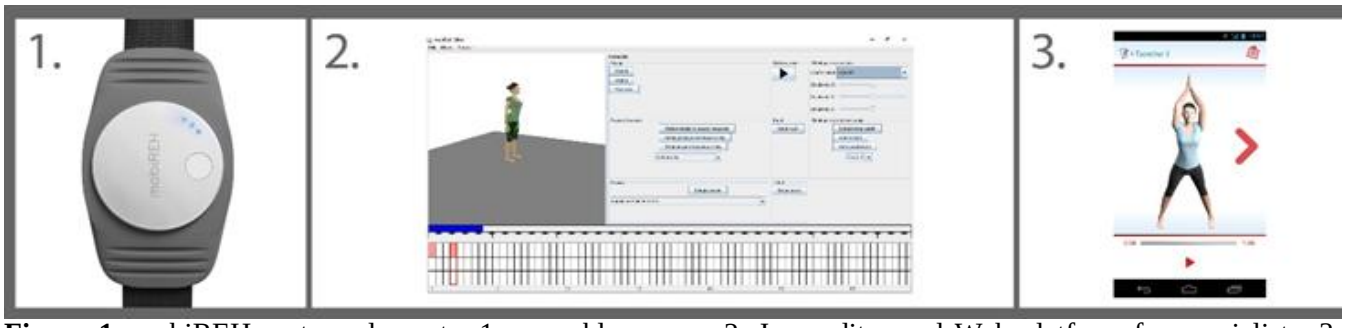

Figure 1. mobiREH system elements: 1. wearable sensor, 2. Java editor and Web platform for specialists, 3. patient app.

College, AGH University of Science and Technology in Kraków, The University of Physical Education in Kraków - AWF). For realisation of the project AWF set up a group of experts. A continuous collaboration with this expert group allowed for constant verification of the correctness of the technological solutions at each step. This allowed conceptual mistakes to be avoided, as well as allowed for development of the most efficient solutions which met expectations of both patients and physiotherapists.

Process

The project began in 2014 with the following aims: (1) assuring safety of home-based rehabilitation, (2) improvement of the efficacy of the final outcome of home-based rehabilitation, (3) development of a tool for efficient motivation of the patient, (4) providing the physiotherapist with clinically significant medical data regarding the rehabilitation process of the treated patient, and (5) streamlining of the communication between the patient and the medical specialist. In order to achieve these goals the following solutions were chosen and rationalised.

Why mHealth?

Remote monitoring of a patient allows for continuous specialist healthcare in many medical fields. It also ensures quick medical intervention in case of emergency and, at the same time, minimises unnecessary visits to a doctor's office. Furthermore, patients feel more motivated to work with and follow their doctor's recommendations, which translates into better treatment outcomes.

Domestic and foreign research shows the readiness of patients to use mobile technologies and remote supporting systems for their healthcare and rehabilitation. Up to 70% of patients want to use these types of solution.[6] Canadian research in 2010 regarding satisfaction of patients using telerehabilitation tools in care after arthroscopic surgery of the knee joint showed that both groups (the intervention group performing at home telerehabilitation, and the control group performing classical rehabilitation) did not differ statistically in respect to the level of satisfaction from realisation of rehabilitation.[7] In 2016 Danish research showed that telemedicine for cardiology patients motivated twice as many patients to continue and finish the entire process of rehabilitation in comparison with traditional rehabilitation.[8]

Why 3D visualisation?

In the initial process of creation of visualisation for the exercises 2D graphics was used. 2D graphics showed key positions of the exercises to be performed, but without showing the continuity of the movement. During the collaboration with physiotherapists it was demonstrated that 2D graphics were insufficient to properly and fluidly visualise the entire movement – resulting in patients having problems with recreating the exercises in home settings. To counter this, 3D visualisation were chosen instead. This properly reflected performance of the actual exercise (fluidly in every dimension). Additionally, it allowed for visualisation of the performed exercises from the perspective chosen by the patient. 3D visualisation also allowed for presentation of the exercise in a way which maintained the continuous flow of the movement, facilitating proper recreation of the exercise by the patient.

Why an Editor?

Java editor consists of three elements: (1) built-in model of 3D characters, (2) control panel allowing for movement of individual parts of the body of the 3D character and addition of voice and text commands, and (3) timeline visualisation of the individual movements. In the process of creation of the exercises it was important to programme the initial and finishing position, as well as the intermediate positions, assigning time values to them. The editor calculated (using a mathematical model) the movement,

assigning a proper rate and scope to it. An unlimited number and kinds of exercises can be designed. Any person with a medical education can independently design an exercise, which will be adjusted adequately to the needs and possibilities of their patients - there is no need to hire programmers or graphic designers to create new exercise sets (this lowers costs, and allows solutions to be applied to other needs).

Why wearable sensors?

The initial goal of the project was to present a patient with a visualised exercise. During the collaboration with physiotherapists the need for continuous monitoring of the patient and the executed exercises was strongly emphasised. In order to satisfy this, and in the light of lack of existing solutions which would be accurate, easy to use, and accessible, we decided to create our own set of wearable sensors.

A combination of three sensors forms an inertial measurement unit: accelerometer (measures physical acceleration), magnetometer (measures direction), and gyroscope (measures angular velocity along one axis). Raw data is processed by a mathematical algorithm, and these data are presented in real-time to the patient and are sent to the physiotherapist to allow monitoring.

Future plans

The final result of the collaboration with the University of Physical Education in Kraków will be the conduct of clinical trials. In the first phase, clinical trials research will focus on verification of the functionality and usability of the solution, both by the physiotherapist and by the patient. The next phase will verify the efficacy of the process of rehabilitation using the mobiREH system in comparison to classical rehabilitation.

Conclusions

Based on this experience the process of multi-disciplinary collaboration during development of the mobile solution was key to successful creation. It underlies the process of creation and allows for its evaluation at any stage. This directly translates into a higher quality of the created product. This in turn translates into a competitive advantage as it ensures the highest quality of the remote rehabilitation experience.

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