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A Cardiac Rehabilitation Program Supported by mHealth Technology: The MOVIDA.eros Platform

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Abstract

The cardiac rehabilitation backdrop in Portugal is lacking much-needed improvements in order to better serve patients with different heart conditions. Although the beneficial results of cardiac rehabilitation are widely acknowledged, it is not being implemented in an optimal way, with few rehabilitation centers irregularly distributed throughout the country. In this context, the opportunity arose to develop a project that would help to fill in this gap.
MOVIDA.eros is an ongoing project aims to bring more people into cardiac rehabilitation programs and help physicians monitor their health anywhere they are. By using a mobile app and a web platform, the MOVIDA.eros project allows healthcare providers to be constantly connected to their patients and see whether they are following their recommendations and adhering to the program. In this paper, an overview will be provided on the current situation of cardiac rehabilitation programs in Portugal, including the main weaknesses and issues that should be addressed. The main features of both the mobile app and the web platform will also be discussed, as well as any challenges that might have come up during the development process.

1. Introduction

Cardiac rehabilitation is an important part of cardiovascular health programs and has been proven to have effective results in patients who have experienced health events such as a stroke or heart failure or who have undergone procedures such as angioplasty or heart surgery [1]. Although its results are widely acknowledged, the Portuguese healthcare system does not provide as much Cardiac Rehabilitation Programs (CRP) as needed, with few rehabilitation

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centers distributed throughout the country. In addition to the lack of cardiac rehabilitation centers, their irregular distribution throughout the country (e.g., there are no public rehabilitation centers in Minho, Trás-os-Montes, Beiras, Ribatejo, Alentejo and island regions) [2] is another major issue that needs to be addressed. It has been shown that patients are much less likely to adhere to programs if these require them to travel a long distance, putting accessibility at the top of reasons why patients often do not participate in rehabilitation programs [3]. However, this is not the only reason why Portugal is behind other countries when it comes to CRP and adherence: a culture characterized by the lack of physical activity, the lack of training in this field and the shortage of financial resources also contribute to this situation [2]. In this sense, and considering that accessibility and financial costs are two main barriers that hinder the adherence of patients with cardiac diseases to rehabilitation programs [4], there seems to be a need for some sort of outpatient program that would eliminate these two obstacles, and it was within this context that the MOVIDA.eros project was brought up.

The use of technology within the healthcare context is incredibly widespread, ranging from emergency rooms to operating theaters, hospital wards, among others. Technological tools and devices are extremely valuable to several different areas of the healthcare system, and cardiovascular health and CRP are no exception [5]. In fact, mHealth technologies (how they are currently referred to) consist of using information and communication technologies in support of healthcare-related fields in a cost-effective and safe manner. Considering that the number of patients with chronic diseases has increased (and that heart-related diseases are one of the main causes of death in Portugal), using these technologies is extremely helpful in treating these patients. In addition, the widespread use of mobile devices and equipment (such as smartphones, tablets, etc.) makes it easier for patients to be monitored remotely by their physicians without increasing the associated costs. This is an important issue both for patients, who can avoid travelling to healthcare facilities as often as they would without these devices, and for hospitals and physicians, which can leverage these technologies to be able to monitor several patients at a time and thus reduce the need to hire more healthcare providers to serve an increased number of patients.

The MOVIDA.eros project was created to serve this exact purpose and to be integrated into a CRP (phase II/III upon cardiac risk stratification), allowing physicians to monitor their patients remotely and prescribe them custom exercises that are specific to their health condition and fitness level. It is an attempt to improve the health of patients who suffer from cardiac diseases or who have undergone cardiac procedures and are in need of rehabilitation programs that can help them recover faster and in a safe and cost-effective way.

This paper explains how the MOVIDA.eros project works and provides details about the design and implementation thereof. Section 2 contains information on related work and similar apps and platforms that have already been developed in this field, showing how their success has contributed to the development of our own app/platform. In Section 3, the architecture and the main features of both the web platform (physician-side) and the mobile app (patient-side) are explained in further detail. Section 4, on the other hand, refers some of the challenges found while trying to implement the platform, including issues related to the patient population itself and issues associated with data collection and privacy. Finally, Section 5 includes some conclusions gathered from the work performed throughout the project and what is to be expected from it in the future.

2. Related work

The use of apps and web platforms as a way of improving self-management of heart conditions is not entirely new in the healthcare field. Similar apps and platforms have been created to help patients with heart conditions manage their health at home while staying connected to their physicians or caregivers. Two examples are HeartMapp and Heart Failure Health Storylines, two mobile apps developed for patients to keep track of their health and get information on their specific condition and how to manage it [6]. Similarly to MOVIDA.eros, these apps allow patients to measure vital signs and help make sure that the patient keeps up with the needed levels of physical activity. Another mobile app that stands out from the crowd is PatientConnect. According to the Chief Medical Officer of Penn Care at Home, a program that provides skilled nursing services and other supportive services to eligible patients in the U.S.A., this tablet-based app, created by Health Recovery Solutions, helped reduce the 30-day readmission rate for 130 patients with congestive heart failure by 53 percent [7]. This result proves that mobile apps can effectively help manage patients with this kind of condition and improve their well-being.

Using this as an example of what could be achieved, and realizing how much of an impact these platforms can have, MOVIDA.eros was created as a way of contributing to improving the health of people who need exercise prescriptions and supervision in the context of a rehabilitation program. The integration of a multidisciplinary team, supervised prescriptions, online surveillance and communication features are key to the MOVIDA.eros platform, differentiating this program from the above-mentioned apps.

In this sense, MOVIDA.eros will be integrated into a CRP, namely in phases II and III, and upon the proof of principle (in clinical terms), it will be accessible to be used as a standard tool that physicians can resort to in this key branch of the healthcare system.

3. MOVIDA.eros

The MOVIDA.eros project is meant to be used by patients taking part in a CRP, whether they have a heart condition or have experienced a cardiac event (such as a stroke or heart failure) or because they have undergone a cardiac procedure (e.g., angioplasty or heart surgery). It is also meant to be used by healthcare providers who are in charge of conducting these rehabilitation programs. The connection between patient and healthcare provider is the core of the project and is key to obtain effective results in this context.

The MOVIDA.eros project intends to enable healthcare providers to easily monitor the physical activity of their patients and prescribe custom exercises that are adjusted to their specific condition. It also allows patients to perform their exercises anywhere without the need to travel to rehabilitation centers or other facilities where these programs are carried out. Therefore, patients can easily access and perform tailor-made exercises while keeping their physicians informed about the results obtained during the exercise.

The goal of this project is to increase the number of patients participating in CRP without incurring additional costs to hospitals and healthcare facilities (with the recruitment of additional physicians) and without overloading healthcare providers with an increased workload. In addition, to increase adherence to CRP, the project also aims to reduce visits to the emergency room and help patients lose weight along the process, and these aspects will be used as effectiveness measures to assess the success of the project. These specific measures were chosen based on studies showing their usefulness within this context, such as [8].

MOVIDA.eros is composed of a web platform and a mobile app that is available both for Android and iOS smartphones, which makes it accessible to a variety of users. In order to use the platform, healthcare providers only need a computer with Internet access and patients need to have a smartphone to access the app.

3.1. Architecture

The architecture of the MOVIDA.eros project is detailed below, as shown in Fig. 1.

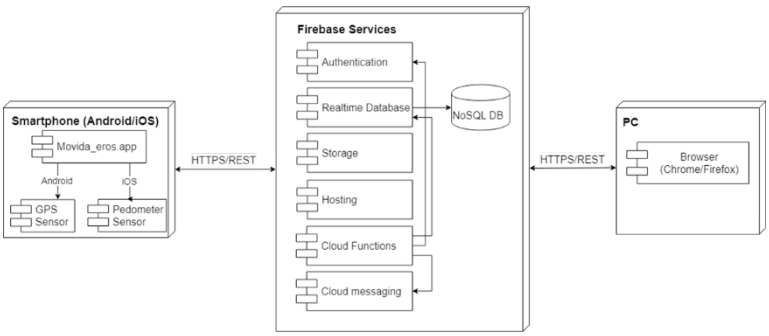

Fig. 1. MOVIDA.eros architecture

MOVIDA.eros is composed of a web platform and a mobile app to be used by healthcare providers and patients, respectively. In order to develop the app for both Android and iOS operating systems, as well as for the web platform, the development framework used was Ionic[1], which allows developers to build both native apps and Progressive Web Apps (PWAs) [9]. This framework was selected for its comprehensiveness as a cross-platform, as it allows for a

quicker and easier maintenance and development process. In addition, the services provided by Firebase[2] were also used in order to connect the mobile app with the web platform and enable them to communicate with each other. These services are: “Authentication” (used to enable users to register and log in); “Real-time database” (used to save all data used within the app and update data in several devices in real time); “Storage” (used to save images and logs); “Hosting” (used to host the website of the web platform); “Cloud functions” (used to run the business logic - this avoids the need to use a specific server for this function); “Cloud messaging” (used to send push notifications to smartphones).

3.2. Main features

As mentioned above, MOVIDA.eros is divided into a web platform and a mobile app to be used by healthcare providers and patients, respectively. The following is a description of the main features implemented on the physician-side and on the patient-side.

3.2.1. Physician-side

After logging into the web platform, the physician has access to a list of patients to choose from. On this web page, the physician can either select one of the listed patients to check their information or add a new patient to the list. When the physician selects a patient, a screen comes up with the patient’s current physical activity prescription and prescription history, with streamlined charts that show every physical exercise performed by the patient, as well as other statistics (Fig. 2). Exercise data are automatically updated on the web platform when the patient completes an exercise, which allows the physician to see the respective details in real time. By clicking on the bars, the physician can check details such as average speed and distance traveled, as well as whether the patient felt any type of symptom while performing that exercise. These charts are easy to read and provide valuable information that allows the physician to check whether the patient is meeting the established goals (when an established goal is not met, the borders of the chart are highlighted in red).

Fig. 2. "Patient" page

Lastly, it is worth mentioning which variables were chosen to assess patient compliance with exercise prescriptions, which was done together with the healthcare providers who were assisting us on the project. The main variables chosen were the period (start date and end date); the type of exercise (i.e., walking); the duration of the exercise; the Borg Scale (rating of perceived exertion, with a pre-established range between 11 and 13, which can be adjusted by the physician); the Karvonen Formula (this allows the physician to determine the maximum recommended heart rate that a patient can reach during an exercise; the physician needs to enter the maximum heart rate and the patient’s heart rate at rest, which is determined at the patient’s initial physical assessment when enrolling in the program); and the diet.

3.2.2. Patient-side

After logging into the app with their credentials, patients have access to a series of information regarding their prescriptions, as well as their profile. These data are only accessible to the physician and the patients themselves, and no other patient can see this information.

In order to start an exercise, the patient needs to go under the "Exercises" menu item (Fig. 3) and click on an exercise under the "Today" tab, which will display a screen with a timer set up by the physician (Fig. 4). After entering the initial heart rate, the patient can finally start walking, bringing their smartphone with them in order to calculate the distance traveled during the exercise, which is done by using the device's GPS system (for Android) or the pedometer (for iOS).

Fig. 3. Exercises - Today" page

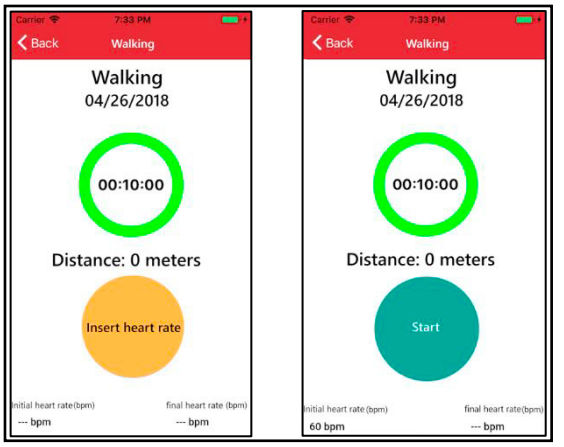

Fig. 4. "Exercise" page

After the exercise is completed, the patient must enter the final heart rate and then select the level of perceived exertion on the Borg scale [10] for that specific exercise. They can also refer whether they felt any symptoms during that exercise. When this process is complete, all the information regarding the exercise is automatically sent to the web platform, where the physician can check all the relevant details.

In addition to performing their prescribed exercises, patients can also see their prescription history and the respective details, as well as information on the diet recommended by the physician and any nutritional advice.

Another important feature is the message inbox. This is where the patient receives notifications about new prescriptions, updates to the current prescription or any prescriptions that have been suspended. The physician can also send text messages to the patient, which is an important part of the patient-physician connection element.

4. Implementation and critical challenges

One of the challenges faced while developing the project was related to the framework used (Ionic). Considering that the project required the use of mobile sensors (such as GPS and pedometer) and other background features, there was the need to install several plug-ins in order to make them work in connection with this framework. Because these plug-ins are often developed by third-parties outside the Ionic framework, it takes longer to correct any errors that may arise. In addition, in the last Android and iOS versions, there were compatibility issues with these plug-ins. In order to solve these issues, it was decided that it would be best to use the GPS system for Android and the pedometer system for iOS, even though the initial idea was to use GPS for both. This is because the GPS system does not run in the background of iOS smartphones; on the other hand, however, many Android smartphones do not support the pedometer plug-in. Therefore, the only option was using a different method for each operating system in order to address these compatibility issues.

Also, it is worth mentioning that one of the critical challenges that has been imposed on this project relates to data protection and privacy. Within the scope of the new General Data Protection Regulation (GDPR), there are a number of changes and updates to data protection policies that need to be taken into account when developing an app that collects user information. In this sense, it is necessary to ensure that the appropriate policies are followed and that the

necessary documentation is obtained to allow us to collect personal information from the patients involved. A request for this certification has already been made. A request has also been made to the Ethics Committee at the hospital where patients will be enrolled in order to approve the use of this app with actual patients.

5. Conclusion and future work

Cardiac rehabilitation is an important part of current healthcare programs both in Portugal and throughout the world. The proven effectiveness of CRP is one of the reasons that urged the development of MOVIDA.eros, a project that aims to positively contribute to the health and well-being of cardiac patients.

Although the mobile app has only been used by beta testers and not actual users, the web platform (physician-side) has, in fact, been approved by the physicians and healthcare providers who will be using it. They have provided continuous feedback and recommendations throughout the process, which was very valuable to the development of the platform. Beta testers have also provided their feedback and suggestions on what could be improved within the app. Both the healthcare providers and the beta testers who used the web platform and the mobile app, respectively, have said that they find this project to be a valuable asset and have stated that they would indeed use it in the future. When the project is transferred to a real-life setting, the main goal is that people will feel motivated to adhere to these programs and perform every exercise that has been prescribed to them, thus contributing to their health and well-being.

Regarding any future work that may be done, the goal is to adjust the app according to the feedback provided by actual patients. This may include changing existing features or adding new futures as may be necessary. One of the goals is to eliminate the need for patients to measure their heart rate manually by using measuring sensors as another option (although most patients that are undergoing cardiac rehabilitation are taught to and can measure their heart rate by checking their pulse). This feature would certainly enrich the app and make it more user-friendly.

In summary, the MOVIDA.eros project aims to fill in a gap that the Portuguese healthcare system has not been able to address – the lack of CRP that can be easily accessed by patients throughout the country. As the project expands and reaches more and more people, the expectation is that the cardiac rehabilitation backdrop will see a much-needed improvement that will help people from all over the country to pursue a healthier and happier life.

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