Prescribe and Monitor Physical Activity Through a Community-Based eHealth Program: MOVIDA Platform

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Abstract

Modern portable devices (e.g. wearables) provide technical support to record physical activity, which can assist various purposes, ranging from geolocation, step count, body temperature and biomedical parameters among others. These technological advances, the increase of literacy in health and also in informatics placed the smartphone and its massive use in the center of a new paradigm of monitoring physical activity. When combining these functionalities with the ability to communicate with remote entities, then it is possible to expand the use of smartphones, not only to monitoring physical activity but also to promote widespread adherence to physical activity programs. This paper presents the conceptual framework of a global health community program centered on a mobile application and a dedicated backoffice web application to perform physical activity prescription and supervision based on dashboards. The MOVIDA platform is comprised of 4 main modules, targeting different groups of the population. This platform enables exercise prescription, monitoring of user's performance and adherence in metabolic diseases patients by MOVIDA.*cronos*, to specify and follow a cardiac rehabilitation program by MOVIDA.*eros*, to track and quantify indoor movements by MOVIDA.*domus*, and also access to a stratified training circuit, for maintaining or improve fitness level by MOVIDA.*polis*. In addition, this work reports the project main challenges from the conceptual phase of the technological platform to its development and implementation. This work can be useful for those who are starting a project with the same type of characteristics: multicentric, interdisciplinary and involving several partners in the community.

Keywords

Mobile app • Mobile computing • Physical activity monitoring • Health and Well-Being • Technologies for life quality

1 Introduction

The use of technology in healthcare is a reality that occurs every day in a wide variety of care contexts. From hospital emergency or surgery departments to the support

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technologies for daily life activities of disabled or elderly, it is possible to find a massive set of technologies to assist technicians, patients, and caregivers. The whole of the technological arsenal has diversified over the last few years and accompanied the various lines of clinical and technological research. Moreover, these technological amenities have been adapted to the needs of healthcare practice and also integrated into the emerging technological devices available in the mass market.

The solutions delivered by the use of technology to contribute to solve the challenges of healthcare are now widely known as eHealth technologies. At the 115th session of the World Health Organization (WHO) Executive Board in Geneva in January 2005, it was recommended the World Health Assembly (WHA) 58.28 resolution on eHealth, acknowledged that eHealth is the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge, and research," and urged member states to develop and implement eHealth technologies [1].

Lifestyle changes associated with modern societies have changed the profile of the most prevalent diseases in the community. Moreover, democratized access to healthcare increased health indicators (e.g., life expectancy, birth mortality), and the number of patients with chronic disease increased. These changes have forced a constant adaptation of health services, which look for eHealth solutions as a support to the effective healthcare. Likewise, citizens are now more skilled in terms of technological literacy, having equipment with a high potential for monitoring (e.g. mobile phones, tables, watches…) that can be enhanced in terms of healthcare without increasing the associated costs [2, 3].

Despite all this new trend of using technologies for improving the quality of life, it is essential to measure their effects on health and also their impact in terms of economic cost-effectiveness. Access to research funding in these areas has increased in terms of European and National projects, reflect European policies for this sector. Some studies, however, have pointed to a large number of eHealth proposals, but suggest that it is critical to realize the true impact and also the safety of proposed eHealth solutions [4, 5].

In this work, the framework of MOVIDA as a Physical Activity Monitoring Platform is presented and the main aspects related to the conception and implementation of the solution are discussed. The work is organized as follows: after the introduction in Sect. 1, in Sect. 2 the four modules of the platform are presented jointly with their objectives and target public. In Sect. 3 the identified challenges and critical points are discussed together with some conclusions.

2 MOVIDA Platform Concept

Chronic diseases prevention and management jointly with rehabilitation programs establish a true challenge to the healthcare community. Epidemiological studies point to an increased prevalence of cardiovascular and chronic diseases and specify the supervised physical activity as a strong mechanism to control the progression thereof [6–8].

The MOVIDA platform is in line with the above concept, by creating a global health community program, centered in a platform with a mobile App, a backoffice, and a dashboard, aimed to monitor physical activity, and is comprised of four main modules, targeting different groups of the population. This program enables exercise prescription and monitor user's performance and adherence, in metabolic diseases patients by (MOVIDA.*cronos*), to specify and follow a cardiac rehabilitation program (MOVIDA.*eros*), to track and quantify indoor movements (MOVIDA.*domus*), and also access to a stratified training circuit for maintaining or improve fitness level (MOVIDA.*polis*).

The above-mentioned modules can be categorized according to whether they are open to the community and also to its main objective as an interventive or preventive program. Accordingly, using the aforementioned conceptual terms MOVIDA defines two axes and two dimensions. The axes include the social network environment that can be open or restricted, while the dimensions refer to the purpose of the actions, which can be interventive or preventive.

As a community-based eHealth program, the MOVIDA platform enrolls the civil society, research, and academia. This project was funded by the Portuguese Foundation for Science and Technology—FCT in the framework of the H2020 research program and is developed by a consortium of several institutions: Polytechnic Institute of Leiria—IPL, Polytechnic Institute of Tomar—IPT, Polytechnic Institute of Castelo Branco—IPCB, Hospital center of Leiria—CHL and Municipality of Leiria—CML. The conceptual framework is resumed in Fig. 1.

2.1 MOVIDA.*cronos*

The increased prevalence of chronic diseases can ultimately be seen as a consequence of the modern healthcare success. In fact, the success in healthcare regarding treatment of acute diseases, combined with the constant research and new treatment approaches, increased the number of patients having chronic pathologies and therefore the need to create structures to deal with this new reality. By definition, these patients are mostly stable, only requiring to be followed up

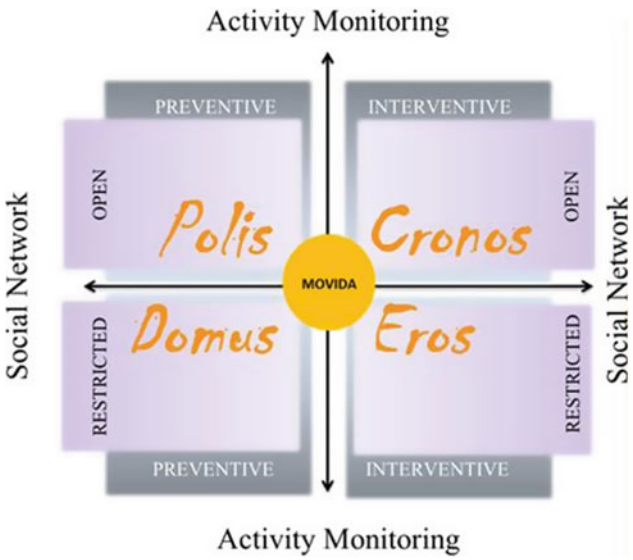

Fig. 1 Conceptual Framework of the MOVIDA platform

in the management of their disease (through remote monitoring, monitoring of daily habits, decompensation of the underlying disease, etc.).

This module is aimed at chronic diseases and it is meant to be used in primary health care (mainly by physicians or certified professionals in the prescription of physical activity) with the purpose of prescribing a personalized and adapted recommendation of physical activity to the user. The target audience is chronic disease patients (e.g. Diabetes Mellitus, Dyslipidemias, Hypertension, Overweight, etc.) who are being followed in primary health care units, for whom it is indicated the practice of regular physical activity [9]. Regarding the conceptual framework, this module is mainly in the intervention dimension and is closed in what concerns to the social network.

In addition to the prescription of physical activity, by means of a dedicated backoffice, it is possible to follow online the adherence of the patient to the clinical recommendation. This functionality enables real-time monitoring and also to enhance the practice of the prescribed recommendation of activity (as if it were the prescription of a medication). When following the recommended training performance, the prescriber can adapt the recommendation as a function of the outcomes of the mobile App. In addition, it is possible to send a message to the user using the dashboard to App communication function, which can also act as a motivational incentive.

By using the dashboard it is possible to prescribe physical activity by duration, frequency, and type. The duration usually defines 30 min as a lower bound, the frequency is defined by the number of days per week, and the activity type can be prescribed in two levels (i.e. walking, running). The automatic outcomes are the overall activity accomplishment level and heart rate measures. Other biomedical variables can be introduced by the user (e.g. Blood Pressure, HLDc, BMI, Abdominal Perimeter) whenever the user aims to enrich the profile. In Fig. 2 is possible to see an overall view of the prescribing dashboard at left, and an overview of the App profile at right.

2.2 MOVIDA.*eros*

This module of the MOVIDA platform is meant to be integrated into Cardiac Rehabilitation programs, in particular at phases III and IV (i.e. the ambulatory phases), creating a dedicated heart-healthy lifestyle change to address risk factors for cardiovascular diseases.

Cardiac Rehabilitation is a medically supervised program for people who have suffered a myocardial infarction or

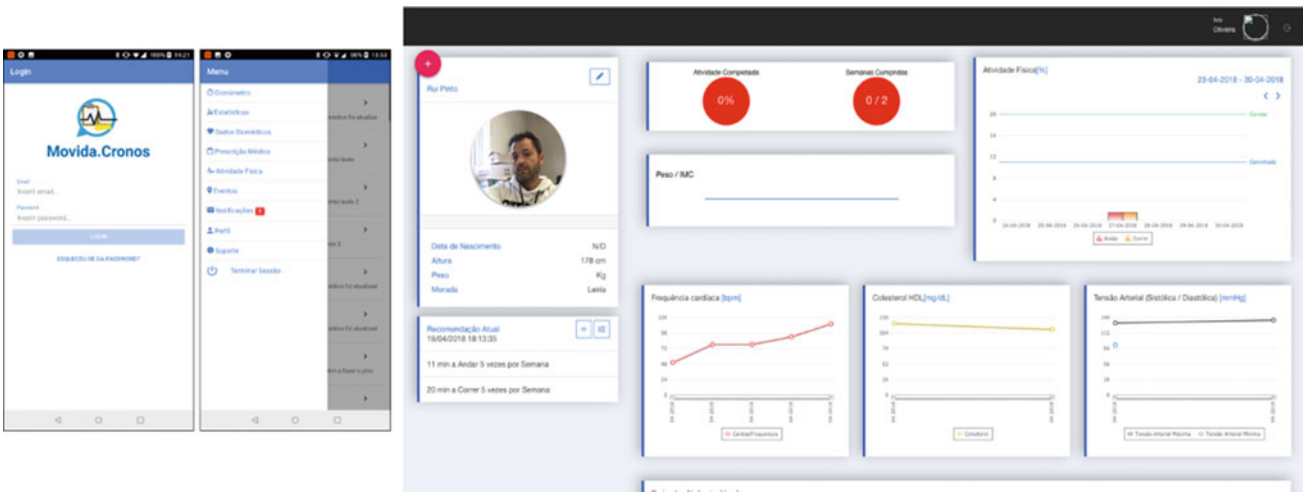

Fig. 2 MOVIDA.*cronos*. Main screen App at left and platform overview at right

acute coronary syndrome, coronary artery bypass grafting, percutaneous coronary intervention, heart failure, heart valve surgery or cardiac transplantation, but also as a prevention for new cardiovascular events. The rehabilitation program aimed to promote physical activity, education about healthy living (healthy eating, medication adherence and stop smoking) and measures to improve mental health [10–12]. Exercise prescription should specify frequency, intensity, duration, modalities, and progression.

These are allowed by MOVIDA.*eros*. Physical activity after a cardiovascular event is seen as having central relevance in the rehabilitation process, and the results in terms of cardiovascular benefits are seen as unequivocal among the medical community. In fact, exercise therapy can have positive effects on depressive symptoms, emotional well-being, cognition, executive functioning and memory, balance, mobility, bone health, walking ability, functional capacity and thus to improve quality of life [13, 14].

In Portugal, the incidence of cardiovascular diseases continues to be one of the main causes of death and in particular the number of ischemic coronary events continues to increase. Health services were not designed to provide a massive response in terms of cardiac rehabilitation (as recommended by the guidelines) and for this reason the integration of the MOVIDA.*eros* module in the rehabilitation plan supported by mobile technology has an impact in terms of provided care without increasing costs. According to the proposed conceptual framework, this module is at the intervention dimension and is closed in what concerns to the social network. Patients will be monitored by the mobile App in each training section (heart rate, Borg scale, adverse events) and the communication Dashboard-App is automatic. The Mobile App also includes dietetic suggestions and tips adapted to the user profile. In Fig. 3 is possible to see the overall view of the prescribing platform at right and the mobile App main screen at left.

2.3 MOVIDA.*polis*

Physical inactivity plays a major role in the chronic disease physiopathology (e.g., cardiovascular disease, diabetes, cancer, hypertension, obesity, depression, and osteoporosis) and premature death [15]. The practice of physical activity is, therefore, a determining factor in the prevention of diseases, but also is associated with better mental health and well-being, and as an ally in the fight against cancer.

The increase of health literacy has contributed to a more attentive society to the positive association between physical activity and health. On the other hand, public policies have been attentive to the benefits of physical activity practice and have contributed to creating conditions for the practice of outdoor physical activity through the creation and adaptation of maintenance circuits, bicycle paths, and anaerobic training equipment in gardens and footpaths. These new practices, however, are not exempt from risk, and it is desirable that the practice of physical activity can be recommended and accompanied by a professional, or at least adapted to the characteristics and performance of each individual.

This identified requirement for guidance and supervision of the practice of physical activity (for safety and performance reasons) can be assisted by mobile technology, and enhanced by the use of artificial intelligence algorithms by adapting the exercise recommendations in function of the users' performance and their perception of effort.

The MOVIDA.*polis* module was initially designed for the polis circuit in the city of Leiria, consisting of a mobile application and a platform allowing the training stations to be adapted to other cities or places. The training stations are identified by reading a QRcode, and the user can choose the exercises that he/she wants to perform.

This module is open in terms of social network and assumes a preventive dimension in the conceptual framework of the MOVIDA platform. In Fig. 4 is possible to see

Fig. 3 MOVIDA.*eros*—three App screens at left and platform overview at right

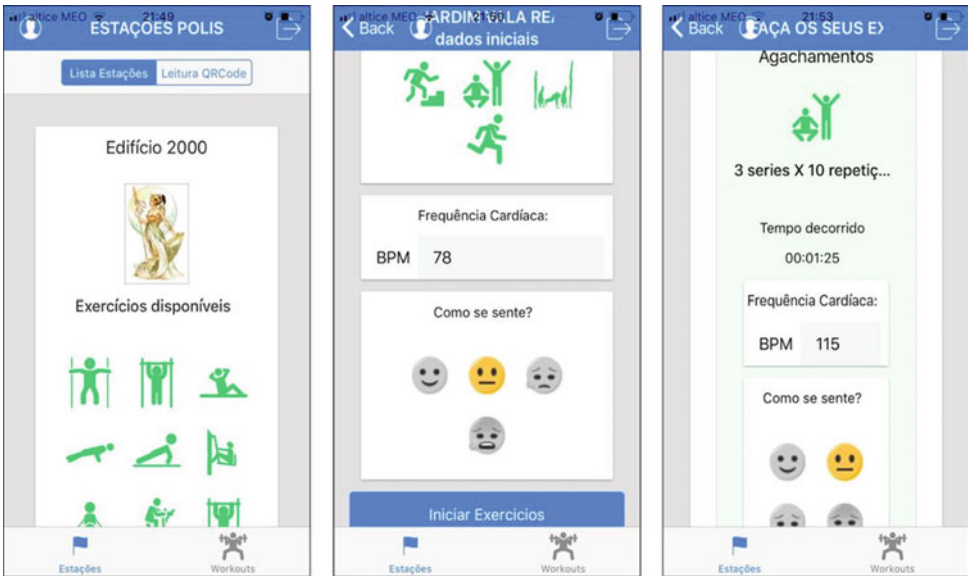

Fig. 4 MOVIDA.*polis*—Example of three App screens

the overall view of the prescribing platform at right and the developed mobile App main screen at left.

2.4 MOVIDA.*domus*

The use of wearables in the remote monitoring of people increased in the last years and its use has been diversified [16]. In particular, it has contributed to the development of research projects in the area of Assisted Living, for example by remote monitoring of vital signs [16, 17]. The output of these research projects has contributed to improving the quality of life of older adults, but also for those how need some kind of assistance in daily life routines. The increasing number of people having a smartphone booted the opportunities of using the available technologies embedded in the phone as a motion sensor (through the accelerometer) and also the position (via GPS).

Human behaviors vary in function of external factors, however, some studies have shown regular behavior patterns associated with the practices of daily living activities. Specifically, in this population typically presenting a reduced capacity of movement and functional limitations. These patterns can be analyzed by task, individually, or by a group pattern in a set of tasks [18]. By aggregating these standardized features, extracting attributes associated with specific tasks, and artificial intelligence algorithms, it is possible to monitor patterns of daily activity and detect changes in these patterns.

The module MOVIDA.*domus* allows tracking this daily activity, as well as the extraction of the movement patterns associated with it. Changes to the activity pattern will generate several types of alarms for the user himself (to be received in his mobile phone and to disarm whenever will be the case), or to the caregiver associated with the user.

These alarms can be classified as inactivity alarms, position alarms or non-response alarms. In the framework of the MOVIDA program, this module is closed in terms of social network and assume a preventive dimension.

The MOVIDA.*domus* architecture is comprised of 5 modules: mobile app; web Platform; firebase services; webservice; and Artificial Intelligence (AI) server, as illustrated in Fig. 5.

3 Implementation and Critical Challenges

The MOVIDA platform specificities (multicentric, interdisciplinarity, communitybased) constitute a true challenge to the research team. One of the first questions is related to the number of enrolled partners and the different areas of specialization. Beyond an operational platform, the challenge is to achieve a functional platform that can meet the expectations of users (health professionals and app users). The definition of the objectives in a language clearly understood by all users is central to obtain a functional platform. It should be easy to use amongst different users, having a distinct technological background. This usability property is designed in the jointly defined set of objectives established in the specifications stage at the beginning of the prosed development. Thus, even in case of some unpredicted deviation from the initially established methodology, the key

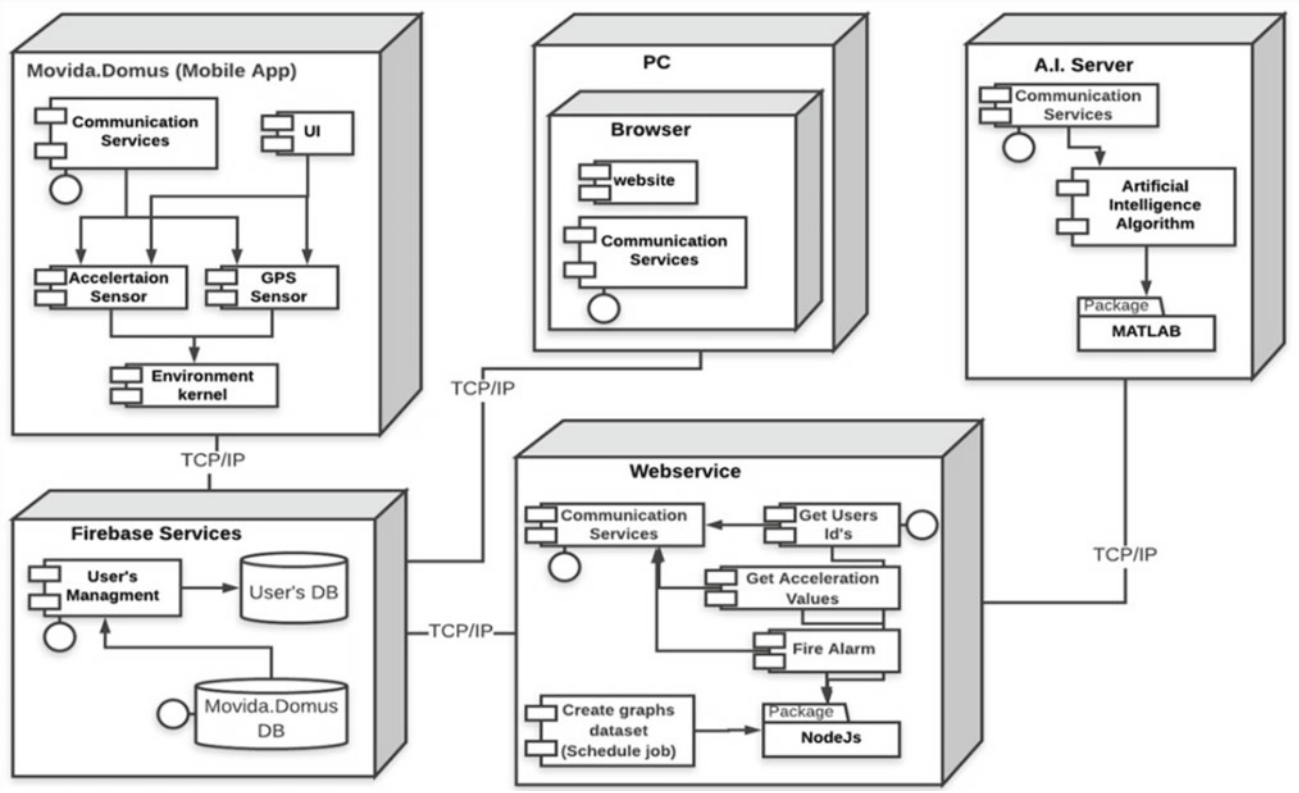

Fig. 5 MOVIDA.*domus* architecture

is to define alternative strategies to attain a solution that fulfills the established functional objectives.

As a platform dealing with personal and clinical data, it is compulsory to assure all legal issues (in accordance with the legislation), but also to protect ethical issues by requesting a referral to a certified ethics committee. In the case of the MOVIDA platform, registration was made with the National Commission for Data Protection in Portugal (CNPD) and an ethics committee approved the Platform proof of principle. Still, due to the type of data that is acquired processed and stored, and to the actions this data can trigger, confidentiality, access control, but also high accuracy levels of the decisionmaking algorithms is compulsory.

Despite the high number of potential users, regarding the proof of principle, it is necessary to involve groups of volunteers who meet the defined inclusion criteria, which is sometimes not easy to achieve. For example, one of the requirements is to have a smartphone and some literacy in terms of its use. To overcome this difficulty, one of the strategies was the implementation of workshop sections explaining the main features of the platform. All of these dissemination strategies were made jointly with the local organizations of the civil society, in particular with the municipality, health and sports students and health services.

4 Conclusions and Future Work

EHealth strategies and technological solutions to optimize healthcare are a reality that is increasingly present in everyday life. The use of mobile applications is a strong ally in this strategy, due to the widespread use of supporting technologies, which does not entail additional costs and it is proven to be effective. A large amount of generated data and its optimized storage will allow researchers to respond to another great challenge by effectively quantifying health gains obtained through eHealth strategies.

Within the scope of this project, a proof of concept is now running for each of the dimensions of the platform, as well as an economic impact study for MOVIDA.*eros* and MOVIDA.*crono* dimensions, whose results will be published in due course.

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