Towards Physical Activity Support Community

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***Abstract*—Nowadays it is recognized that physical activity, besides other lifestyles, has indisputable beneficial affects on cardiovascular diseases prevention and treatment. Additionally the social support is important and has a valuable impact on the outcomes in cardiovascular disease patients. To provide the patients the social support needed and, to support and motivate them in their daily physical activity, we are working on building a mobile virtual community for physical activity support connected to a triaxial accelerometer, where the physical activity will be monitored and the main objective will be to motivate and support the patients to be adequately physically active. In this paper, the main functionalities supported by the community are discussed and the instrumental support is also investigated and metrics, based on the IMA metric, are proposed.**

***Index Terms*—Cardiovascular Diseases, Heart Failure, Hypertension, Instrumental Support, Physical Activity, Social Support, Virtual Community.**

I. Introduction

Cardiovascular diseases (CVD) are a significant cause of mortality and morbidity in the European Union, and result in considerable economic and social costs [1][2]. 80% of premature deaths could be avoided by controlling the main risk factors: smoking, unhealthy died and physical inactivity. Some health organizations (such as ESC[1] and AHA[3]) recommend CVD patients to adopt some lifestyle changes such as being physically active. Physical activity is any bodily movement produced by skeletal muscles, that results in energy expenditure[4]. In the literature [5], a linear relationship has been reported between the energy expenditure and body acceleration due to the body movements. Physical activity in daily life can be categorized into occupational, sports, conditioning, household, or other activities[4].

AHA and ESC recommend CVD patients and older people in general to be physically active based on the gained benefits such as that the physical activity (PA) prevents, manages and reduces high blood pressure, provides a way to share an activity with family and friends, boosts energy level, and maintains quality of life and independence longer. But, there are some common perceived barriers for older people [6] (CVD patients are mostly elderly people) for being physically active, such as lack of time and motivation, physical limitations, lack of knowledge and stereotyping (for example, the perception that older people and especially CVD patients do not have to exercise because of their health state).

When patients are socially supported, they can comply more to the physical activity. A literature study[8] was conducted to get the impact of social support on the outcomes of HF patients, especially readmission, mortality, quality of life and depression. Authors affirm that the social support for patients with HF (could be extended to CVD patients in general) is a strong predictor of hospital readmissions and mortality. Patients with poor social support have a higher risk of mortality and hospital readmissions. There are various types of social support: emotional support, appraisal support, informational support, and instrumental support[7]. Currently, there are many ICT-mediated solutions such as the virtual healthcare communities that aim to provide patients the needed social support, especially emotional and informational support (see section II for more details). It is presumed that the virtual communities improve the patients' motivation. In this direction, we are investigating in building physical activity mobile virtual community (MVC) for CVD patients with the use sensor technologies (accelerometer). Activity monitoring based on an accelerometer sensor is an useful method to obtain objective information about the daily physical activity patterns and the related energy expenditure [10][9][5]. The IMA metric proposed by Bouten[11] will be the basic metric supported. The MVC will provide mainly the instrumental and appraisal support. The challenge will be to couple the social support model, as a motivation theory, with another one wildly uses in health purposes: the Transtheoretical Model[12] to motivate patients to be adequately physically active. The action and maintenance stages Transtheoretical Model are the most challenging within the MVC.

In this paper we are providing an overview about the functionalities of the MVC and instrumental support provided within the community. Monitoring the patients' physical activity, in term of energy expenditure, is the instrumental support core. For this aim we need some metrics, besides the IMA, which are presented here. The outline of the paper us as follows. Section 2 presents related works and section 3 presents an overview about our mobile virtual community. Then, in section 4 we present the instrumental support that will be provided within the community and in the last section we present a discussion and some conclusions.

II. Related work

The virtual healthcare communities are in perpetual evolution/increasing to help either patients or healthy subjects to be more physically active. They provide social support (mainly emotional support and informational support) about the physical activity via , for example, blogs, forums, newsletters, videos and pictures sharing, and support groups. Some of those communities involve the professional caregivers and/or informal caregivers (family, neighbours and friends). We can cite some examples of those communities: PatientsLikeMe [13], RevolutionHealth [14], WebMD [15] and HeartPatient [16], DailyStrength [17] and CureTogether [18]. Google groups [19] and Yahoo groups [20] also provide some e-support group for patients; Google groups proposes around 290 support groups for CVD-related conditions, yahoo groups proposes around 230 groups for heart diseases and 22 groups for hypertension. Facebook [21] offers social support too via its groups and fun pages turned into informative pages. Even more, some Twitter [22] accounts are created to support CVD patients and keep the followers informed about the news regarding their diseases.

From another perspective, there are some Tele-monitoring systems (where some of the systems use one or more wearable device such as a pedometer or an accelerometer) that help patients or healthy people to comply to the physical activity. They allow the caregivers (for example general practitioners and cardiologists) to follow the patients and give them feedbacks. Some of these systems allow the patients to share their physical activities with their friends. Examples of those systems: UbiFit[23] that encourages individuals to self-monitor their physical activity and Shakra[24] that tracks the daily activities of people carrying phones and allows sharing data between friends to increase the motivation for doing physical activities.

The main drawbacks noticed in these communities is that some of them provide mainly two kinds of social support (emotional and informational), some others include in the network either the formal or informal caregivers, and some are focusing in healthy people (teenagers for example) or in general health conditions. In our solution, we want to provide CVD patients with all kinds of needed social support (informational, emotional, appraisal and instrumental) to help them to be physically active with overcoming the perceived barriers, and involving their formal (for example nurse, cardiologist and therapist) and informal caregivers (for example friends and family).

III. Physical Activity Support Community Overview

To give the overview of the functionalities of the physical activity support community, we used the UML use case diagram (Fig 1). The main actors involved in the system and the actions that they can perform are:

- Patient: Does his or her daily physical activity, shares his/her daily activities, sees his/her PA records and overall activities and see, when allowed, the activities of his/her network.
- Cardiologist: accesses the physical activity report of his patients.

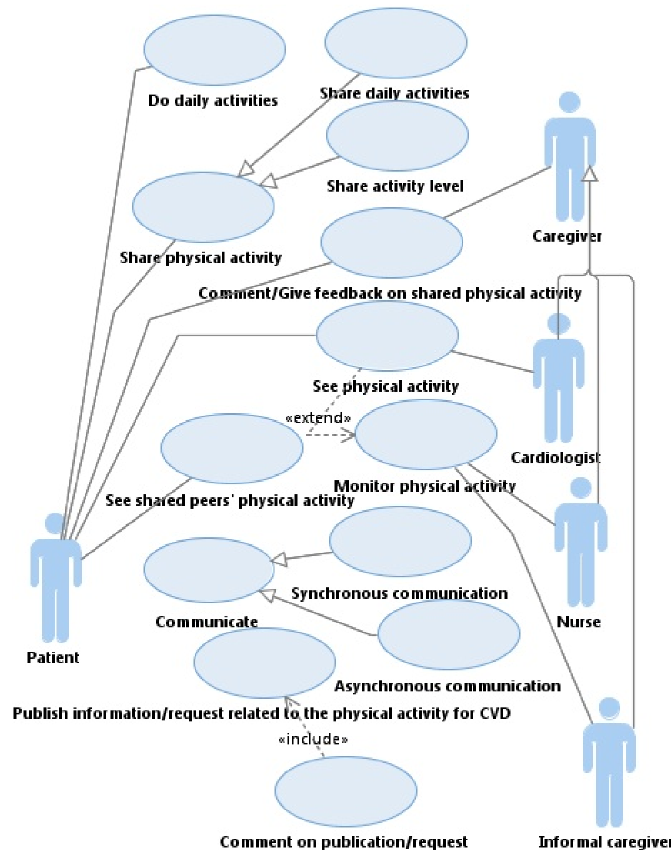

Fig. 1. Use case diagram

- Nurse: monitors the physical activity of patients, to report some problem if occurs to the cardiologist, or to provide feedback to the patient.
- Informal caregivers: monitor the physical activity of their related to provide feedback and encouragement.
- Patient and caregivers can have one-to-one or multiple asynchronous or synchronous communications when it is needed. They can also share/publish information related to the physical activity for CVD patients (example text, videos and pictures), request help/advice reply to existing posts or requests.

IV. The Social Support and Its Fulfilment in the Physical Activity Support Community

As stated before, we want to handle the four types of support (emotional, informational, instrumental and appraisal) within the physical support community. In this paper we will focus more in the Instrumental support.

A. Instrumental Support

In addition to the access to the MVC, the patients will get an accelerometer sensor. Accelerometers provide a portable, simple, affordable, objective, and socially acceptable method of measuring the amount of physical movement associated with free-living PA [27]. More specifically we will use a triaxial accelerometer, to measure daily physical activity and

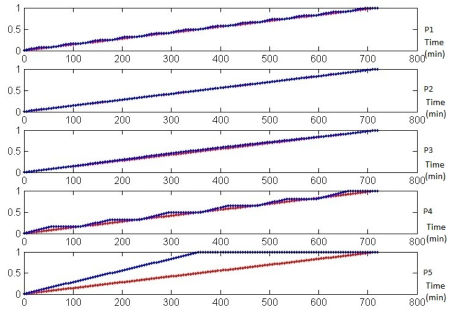

Fig. 2. IMA_R Vs IMA_M, simulated with 5 subjects

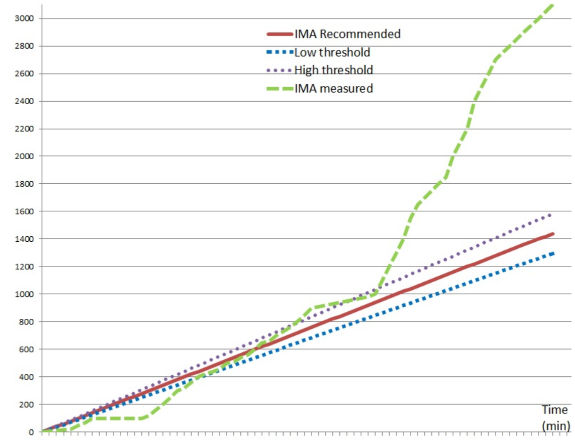

Fig. 3. The IMA_R, IMA_M, with the low and high thresholds

the associated energy expenditure, coupled with the algorithm of Bouten [5]. It proposes the IMA metric for measuring the physical activity:

IMA=$\int_T^{T+M} |a_x(t)|\,\mathrm{d}t + \int_T^{T+M} |a_y(t)|\,\mathrm{d}t + \int_T^{T+M} |a_z(t)|\,\mathrm{d}t$
where x, y and z are the axes of the accelerometer and a_x, a_y and a_z the associated accelerations.

With the use of this metric the physical activity can be measured (IMA measured IMA_M) during the day and compared to a recommended physical activity level (IMA recommended IMA_R). From this comparison we get information about the personal achievement, but also can serve to compute the group achievement toward a group goal when it is set.

The IMA_R level will be relative to the patient, it could be the PA level of the day before or the average over some previous days. In the Roessingh Research and Development centre[25], researchers interested in monitoring low back pain and COPD patients measured the PA level of control groups [26] to be able to compare it to the PA level of the patients based on Bouten algorithm. We will make decisions on how to get the patterns of the IMA_R level for CVD patients. Fig 2 represents some examples about the IMA_R and IMA_M patterns.

After getting the IMA_R level, the question will be how to compare the IMA_R level and IMA_M level. Two calculation methods were thought about, and some stimulation were done with the of Maltlab to check their validity. The data were generated for 12 hours, where in each 5 minutes there is a measured value.

- 1^{st} approach:
  1^{st} *step:* Define threshold (see Fig 3, where they are a relative deviation from the IMA_R): it means that if the patient is between those two values and close to the IMA_R then the patient is considered compliant to the recommended physical activity level. If the patient is above the high threshold then he/she is over-active, and if he/she is under the low threshold then he/she is considered under-active.
  2^{nd} *step:* By the end of the calculation interval (like a day), compute the percentages of being between the two threshold (P_c), being above the high threshold (P_h) and being under the low threshold (P_u).
  3^{rd} *step* (proceed to the group level) Compute the previous percentages for all the subjects composing a group.
  4^{th} *step:* Compute the root mean square (RMS) of P_c, P_h and P_u:
  $RMS(P_i) = \sqrt{\frac{1}{n}(P_{i1}^2 + P_{i2}^2 + ... + P_{in}^2)}$, where i=c,h,u
  Having the 3 values, the group objective will be to:
  - maximize the compliance percentage.
  - minimize the over-activity percentage and the under-activity percentage.
- 2^{nd} approach:
  The individual goal:
  At each measurement time we compute the personal deviation (PD) (the difference between the IMA_M and the IMA_R).
  PD = $\frac{IMA_M - IMA_R}{IMA_R} * 100$ %(Fig 4 for illustration).
  The objective will be that the subject minimize as much as possible the PD. High and a low thresholds can be defined, where the subject has a bigger tolerance for the deviation.
  The group goal (GG):
  The group goal is defined such as the group performance (GP) reaches 100%, where the maximum percentage of the member's participation (MP) is $\frac{100}{N}$%; with N the total number of participants.
  Same as the previous method we set a high and a low thresholds for the deviations (for example +/-5%). We define a personal deviation within the group (PDG) where(Fig 4 for illustration):
  - If PD $\in$ [high_threshold, low_threshold] then PDG$\leftarrow$0%
  - If PD $>$ 100% then PDG$\leftarrow$100%
  - If PD $<$ low_threshold then PDG$\leftarrow$ $|$PD$|$
  - Else PDG $\leftarrow$ PD

  The contribution of the participant i (P_i) to the group goal realization: GP(P_i) = $\frac{(100 - PDG(P_i)) * MP}{100}$ %
  We can say that: P_i is only contributing by GP(P_i)% instead of the MP% needed for the group performance, and $\frac{GP(P_i)*100}{MP}$% instead of the 100% individual participation to the group goal.

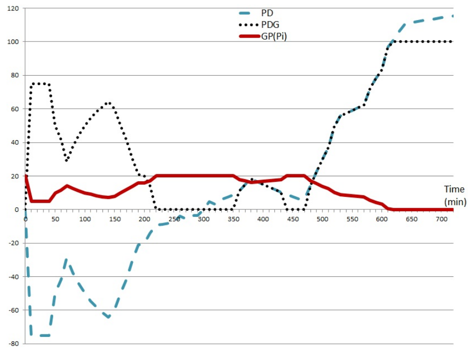

Fig. 4. PD, PGD and GP(P_i) for an individual i, where N=5

Then, the Group Deviation (GD) caused by P_i:
GD(P_i) = 100 - GP(P_i)
Finally, The group performance is:
GP = $100 - \sum_{i=1}^{N} GP(P_i)$

Some parameters will be configurable such as the IMA_R and the associated thresholds, the measurement frequency and the data display. The IMA_R and related thresholds are variable from one patient to another according to their heath situation. It will be set by the professional caregiver and updated according to the evolution of the health state of the patient. The frequency of measurement (for example each 10 seconds or 5 minutes) will be configurable according to the needs and the medical advice.

The result(either in the individual level or the group level) is shown to the patient, to the peers, to the formal caregivers and informal caregivers.

V. Discussion and Conclusion

For the instrumental support, we tried to find metrics, based on the IMA metric, that will be useful in later stages of the work. The adequate interpretation of those metrics will serve to a better feedback/ appraisal support. The way how data will be displayed in addition to the frequency/time granularity (each hour or day period such as morning, afternoon and evening) and visibility (who can see what) is still an open issue. The source (for example feedback from the system, feedback from the peers and feedback from the professional caregivers) the modalities (for example textual and vocal), the frequency (for example when an event occurs such as the patient is too over-active) and the display of the feedback will be investigated in later stages of the research.

A question arises: once implemented and used, will MVC be as effective as planned? For this aim we are planning to evaluate the effectiveness of the community and the real added values which the patients can benefit and how his health will improve comparing to other patients not using virtual communities.

The MVC will play also an important role in overriding the perceived barriers for being physically active. Since the MVC will be running as well on the phone, the member will be motivated to do some physical activity in group, for example, if he or she has some free time in the middle of a busy day and it will not be costly, for instance. The weather conditions will not be a barrier. And finally each member will have a different recommendations according to their physical limitations and the MVC will warrant that the patient doesn't go above it.

This papers presents the first steps toward building a Physical Activity Support Community for cardiovascular diseases patients. We presented also the main functionalities within the Physical Activity Support Community. We explored mainly the instrumental support and needed metrics to support it. The implementation is an on-going work and there will be trials to measure the efficacy of such a community for CVD patients.

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