



The SharedHeart Approach: Technology-Supported Shared Decision Making to Increase Physical Activity in Cardiac Patients

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Abstract. After a cardiac event, patients typically enroll in a cardiac rehabilitation program in a rehabilitation center, where physiotherapists guide them in overcoming their fear to move and increasing physical activity. Effectively changing patients' health behaviour and bringing the newly formed habits to their home environment remains challenging. At home, patients experience difficulties interpreting exercise targets and monitoring physical activity. To bridge the gap between supervised rehab in the center and regular exercise in daily life, we propose a shared decision making (SDM) approach SharedHeart that supports patients in changing their health behaviour and transferring the knowledge and healthy habits to their homes. We developed 3 applications that support patients and physiotherapists in following a SDM approach: (1) a tablet app to record the patient's sports preferences, (2) a caregiver dashboard to create and follow up on a patient-tailored exercise plan during and in between SDM encounters, and (3) a mobile app to report and follow up on physical activity at home. In this paper, we present the results of our survey investigating physiotherapists' application of SDM in their current practice and perceived usefulness of SDM and supporting tools. Next, we discuss our proposed SDM approach on the conceptual level and the guideline-based design of the supporting IT applications. We conclude by highlighting how our approach and tools align with physiotherapists' needs.

Keywords: Shared decision making · Physical activity · Cardiac rehabilitation · Patient empowerment · eHealth

1 Introduction

After an acute ischemic heart disease event, secondary prevention (including cardiac rehabilitation) is recommended by evidence-based guidelines to improve functional capacity, prognosis, and quality of life [2, 23, 25, 28]. Cardiac rehabilitation (CR) is a comprehensive, multidisciplinary program composed of several key components, such as medication, healthy nutrition, smoking cessation, stress management, education, and physical activity. It has been proven that CR is effective in improving quality of life, and reducing both morbidity and mortality. Despite these demonstrated benefits, CR remains underused in current practice [19, 22]. The EUROASPIRE surveys [8] concluded that only 40% of cardiac patients reached the physical activity target at 6 months after hospital discharge. In our current research, we focus on improving cardiac patients' adherence to physical activity with support of IT tools, while still being embedded in a multidisciplinary CR program. The research findings on the use of the digital SDM tools in this context are likely to be generalizable to a broader rehabilitation context.

1.1 Current Practice

In Europe, the cardiac rehabilitation program is typically divided in three subsequent phases. *Phase I* starts when the patient is hospitalized after an acute cardiac event, and focuses on early mobilization and brief introductory counseling. At hospital discharge, patients proceed to *Phase II*, which is usually a supervised ambulatory outpatient CR program in a hospital or rehabilitation center. Here, patients are supported by a multidisciplinary team in managing and reducing their risk factors for about three months. During the rehabilitation sessions, they focus on increasing the patient's physical activity. Patients are guided by physiotherapists while performing exercises on for example stationary bikes, treadmills, and arm bikes [19, 22]. Unfortunately patients regularly skip rehabilitation sessions due to varying reasons, such as personal feelings and beliefs (e.g. embarrassment about exercising in group), system and service barriers (e.g. contradictory advice from the healthcare team), and logistic limitations (e.g. lack of transport and parking) [21]. Moreover, patients are instructed to exercise at home on days that they do not go to the rehabilitation center. Given their age and often sedentary lifestyle, most cardiac patients are not accustomed to performing non-supervised exercise training at home [24] and have fear to exercise. Behaviour change is a complex process, requiring people to restructure their priorities, and daily and social routines [17]. However, patients lack guidance on how to integrate exercise into their daily life and how to exercise independently at home [24]. When patients finish the outpatient CR program, they advance to *Phase III*, the lifetime maintenance or long-term outpatient CR phase, where the support of the multidisciplinary team is reduced. Patients have

to maintain their physical fitness and perform additional risk factor reduction more independently [19,22]. Patients often experience difficulties in transferring the knowledge and habits formed during supervised rehabilitation in the center to the unsupervised rehabilitation at home. It is a challenge for them to interpret their overall rehabilitation targets, identify the physical activities they should do, and monitor their progress over time [24].

1.2 Telerehabilitation

Telerehabilitation can provide a possible solution to cope with the low attendance rates at rehabilitation sessions and the low long-term adherence to recommendations. In telerehabilitation, patients are not restricted to the hospital or rehabilitation center, but rehabilitate remotely at home supported by interactive applications and technology. Reviews [4,11] concluded that telerehabilitation can be a feasible and effective add-on or alternative compared to conventional in-hospital cardiac rehabilitation, and has the potential to support patients in adhering to the recommended level of physical activity. However, telerehabilitation solutions need to be personalized and tailored to the patient's individual condition and needs [10]. Patient involvement is a prerequisite for good clinical practice. In this regard, research has shown that shared decision making has the potential to improve patient satisfaction, adherence, and psychological and physical well-being (e.g. quality of life, anxiety, and depression) [15]. Patients prefer to share decisions or at least give their opinion about treatment before the physiotherapist makes a decision [9]. However, the rather paternalistic model where caregivers decide for their patients is still dominating in practice [7,9]. Accordingly, in most telerehabilitation systems targeting physical activity, patients have only limited input in their exercise prescription and plan.

1.3 Shared Decision Making

Shared decision making is an approach that combines the patient's personal preferences, goals, values, and context with the clinical evidence and expert opinions to make an informed decision [18,27]. To design and develop a personalized telerehabilitation solution targeting physical activity, we propose to incorporate shared decision making (SDM) as a means to involve and empower cardiac patients in the process of constructing an exercise plan. In this context, from the patient's perspective, their current habits, sport preferences, and physical disabilities or limitations should be considered. For example, a dog lover will prefer going for a walk with his/her dog over cycling. On the other hand, the evidence-based guidelines for physical activity and the expertise of the caregivers guiding the patient in the rehabilitation center should be taken into account when making decisions about the patient's physical activity.

1.4 Our Proposed SharedHeart Approach

In this paper, we propose SharedHeart, a technology-supported shared decision making approach for physical activity. Given the fact that currently most healthcare decisions are made by caregivers [7,9], we investigated physiotherapists' current practices of SDM and perceived usefulness of SDM and using SDM tools in a survey. Using our SharedHeart platform, patients and their physiotherapists set up goals together to construct a tailor-made exercise plan in order to get patients involved to make their own decisions. As such, we want to bridge the gap between supervised and unsupervised rehabilitation and improve long-term adherence to physical activity recommendations. The SharedHeart platform is composed of three applications: (1) a tablet application to record the patient's preferences for physical activity, (2) a caregiver dashboard to create and follow up on a patient-tailored exercise plan during and in between SDM encounters, and (3) a mobile application for the patient to report and follow up on physical activity at home. The caregiver dashboard was designed by applying the guidelines of Bonneux et al. [6] for the design of SDM tools targeting health behaviour change. We conclude by highlighting some directions for future research.

2 Physiotherapists' Opinion About Shared Decision Making

In general, shared decision making is not yet applied extensively in clinical practice [7,9]. When designing tools to support caregivers in SDM, important factors influencing uptake of these tools are caregivers' willingness to do it and their acceptance of SDM tools. Given the focus of this paper on physical activity in phase II cardiac rehabilitation (CR), we assessed physiotherapists' current practice of SDM and their perceived usefulness of shared decision making and SDM tools for physical activity in the context of phase II CR. We conducted a custom-made survey with ten physiotherapists working in the rehabilitation center (i.e. ReGo) of Jessa Hospital (Hasselt, Belgium). In the rehabilitation center, cardiac patients are supported by a multidisciplinary team, consisting of cardiologists, physiotherapists, dietitians, psychologists and social nurses in recovering from a cardiac incident. The rehabilitation program for a patient lasts three months and consists of 45 multidisciplinary sessions (individual and in group). The physiotherapists that participated in the survey had varying experience in CR, ranging from physiotherapists guiding cardiac patients during their exercise training half a day per week to daily, to a trainee and the head of the rehabilitation center.

Given the target audience of the survey, we only included questions in relation to SDM for physical activity and exercise training as part of phase II rehabilitation in the rehabilitation center. The survey consisted of four parts assessing physiotherapists' current practice of SDM, usefulness of topics for discussing with patients, usefulness of a tool during discussions with patients and preferences for

conversations about physical activity. Questions about usefulness were 5-point Likert scale questions, ranging from not useful at all to very useful. Questions about frequencies and timing for SDM were multiple-choice questions, but also some open questions were included to gain deeper insights into physiotherapists' preferences.

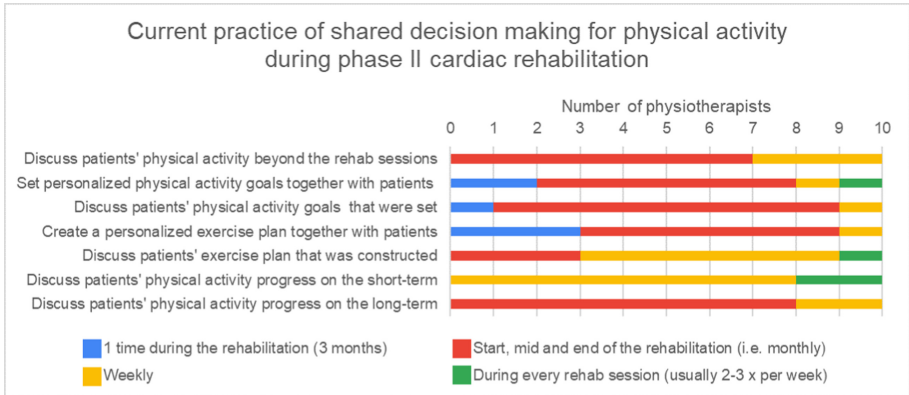


Fig. 1. Physiotherapists' current practice of shared decision making for physical activity during phase II cardiac rehabilitation.

We assessed physiotherapists' current application of SDM in their daily practice by asking them about their interaction with patients. For a selection of physical activity related topics, we collected information on how frequently they discuss these topics with their patients (i.e. perform shared decision making). The results are depicted in Fig. 1. The most frequently discussed topic is patients' short-term progress for physical activity, which is discussed by all physiotherapists at least on a weekly basis. For all other topics, several physiotherapists indicated a lower frequency of SDM (e.g. monthly or only once during the rehabilitation program). Creating a personalized exercise plan together with the patients is done the least frequently, with only one physiotherapist discussing it on a weekly basis, six physiotherapists discussing it monthly, and the remaining three physiotherapists only discussing it once during the rehabilitation.

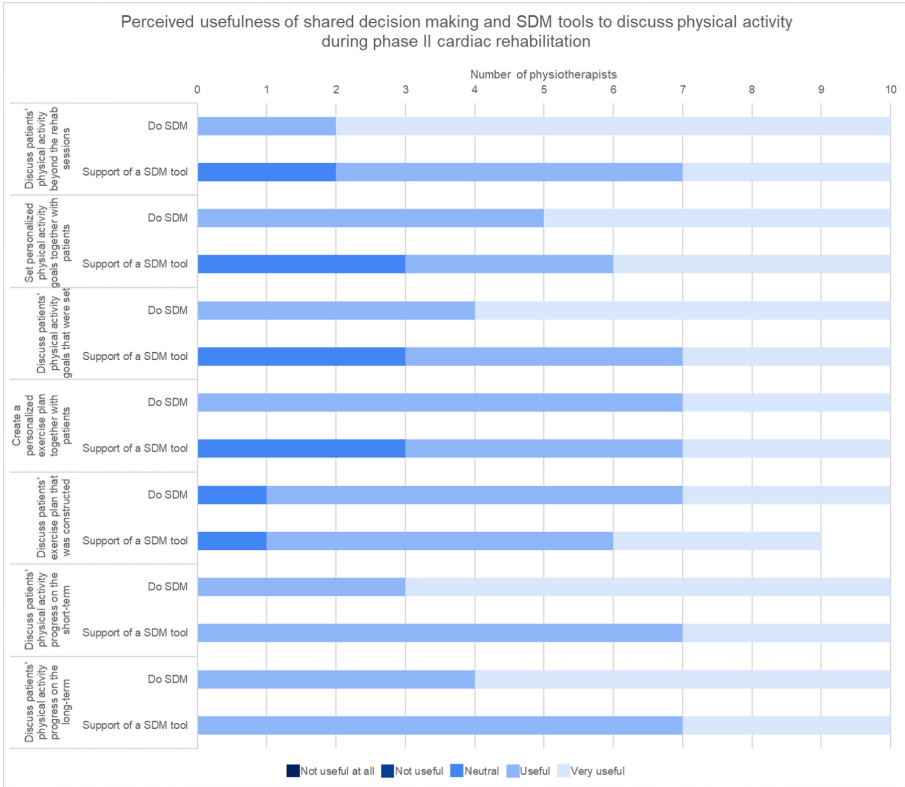


Fig. 2. Physiotherapists’ perceived usefulness of shared decision making (SDM) and using a SDM tool to discuss physical activity during phase II cardiac rehabilitation.

Secondly, for the same set of physical activity related topics, we assessed physiotherapists’ perceived usefulness of 1) shared decision making (i.e. discussing these topics with their patients) and 2) receiving support of a SDM tool during these discussions. The results are depicted in Fig. 2. In general, physiotherapists perceived for all topics shared decision making as valuable. Only for one topic (i.e. discussing patients’ exercise plans) one physiotherapist indicated neutral, but for all other topics all physiotherapists indicated that it is (very) useful to discuss them with their patients. Discussing physical activity that patients do next to their rehabilitation sessions in the center was identified as the most useful discussion topic, followed by discussing patients’ short- and long-term progress and physical activity goals.

Physiotherapists’ perceived usefulness of a SDM tool to support the discussion of physical activity related topics was slightly more neutral, indicated by a higher number of neutral responses. Nevertheless, no physiotherapist indicated that he/she would not find it useful to use a SDM tool. There were no topics that clearly stood out as the most or least useful to discuss with the aid of a

SDM tool. The slightly lower perceived usefulness of a SDM tool compared to doing SDM could be due to physiotherapists' current way of working and the fact that they did not have any experience with a SDM tool and we did not give them a detailed explanation of the possible features of such a tool.

Lastly, we asked physiotherapists about their preferences for timing of conversations about physical activity with their patients, i.e. when would they find it useful to have these conversations and what is the preferred frequency. Most physiotherapists (8/10) indicated that they would find it useful to discuss their patients' physical activity every week during the rehabilitation program in the rehabilitation center (i.e. the entire phase II cardiac rehabilitation). Varying reasons were indicated for this, including the importance of physical activity in the rehabilitation process, patients' need for evaluation and confirmation, easy integration into training sessions, influence on motivation and involvement, working efficiently, adapting timely and detecting problems. Some physiotherapists also noted that it is especially important to discuss the physical activity that patients do next to their rehabilitation in the center. The two other physiotherapists indicated varying moments for conversations about physical activity. One physiotherapist would prefer the combination of the first and last 6 weeks of the rehabilitation program and at the long-term follow-up. As such, the buildup and progress at home and during the rehabilitation goes in parallel with the cardiopulmonary exercise test that was done in the rehabilitation center. Another physiotherapist would prefer the combination of biweekly discussions during the rehabilitation program, with closer follow-up in the first and last 2 weeks, plus at the long-term follow-up. The physiotherapist noted that it should not be too frequent, because it should be organizationally feasible and it should be possible to detect progression or stagnation. On the other hand, it should be discussed frequently enough to increase or sustain motivation and to provide a broader reference frame for the physiotherapist.

We also assessed physiotherapists' preferences for the frequency of conversations with patients about physical activity. The frequency varied: 4 physiotherapists preferred weekly, 4 physiotherapists preferred biweekly, 1 physiotherapist preferred both weekly and biweekly and 1 physiotherapist preferred monthly. One physiotherapist noted that it could be frequent in the beginning but with a degrading frequency, ranging from every session to once a month. Reasons for these frequencies included allowing for checking up on and guiding the patient, providing patients a clear goal to train and make progression, updating the training parameters more adequately (e.g. number of repetitions and sets), stimulating patients frequently to continue exercising at home, following up patients and adjusting the training when needed, detecting problems and possible pitfalls, adapting short- and long-term goals, and keeping the overview of the patients' physical activity. Some physiotherapists noted the importance of having enough time to do the rehabilitation exercises. Furthermore, adapting exercise habits requires time. On the other side, there should be enough time for a decent discussion. For both the current and preferred frequency of SDM, the diversity in answers may be due to a physiotherapist's interpretation of a SDM moment,

varying from briefly asking how the patient is doing to having a decent conversation about the patient’s activity.

We want to conclude the presentation of the results of our survey by mentioning that we did not investigate explicitly how physiotherapists perceive the time they spend discussing with their patients. However, this could have an influence on their perceived usefulness of shared decision making and SDM tools.

3 Decision-Making in the SharedHeart Approach

Shared decision making (SDM) for physical activity during the supervised ambulatory outpatient cardiac rehabilitation program (phase II) is one of the key topics in our current research. To support patients in exercising at home during phase II and bridge the gap between supervised and unsupervised rehabilitation, we propose a SDM approach supported by a digital platform, SharedHeart.

3.1 Approach for the Rehabilitation Program

During phase II cardiac rehabilitation, patients come two to three times a week to the rehabilitation center to train under the supervision of physiotherapists. In the SharedHeart approach, we combine these training sessions with SDM encounters supported by digital tools. Ideally, from the first week of the supervised rehabilitation onwards, the patient has once a week a SDM consultation with a physiotherapist to discuss his/her physical activity.

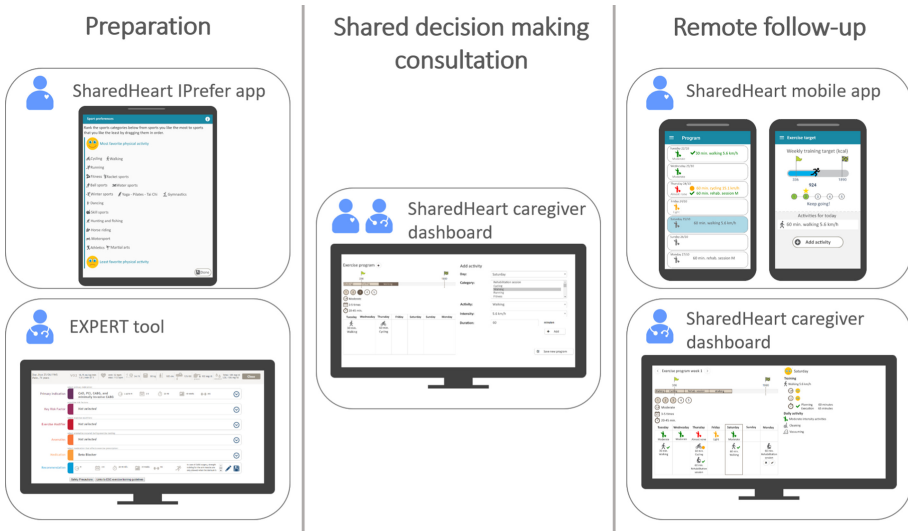


Fig. 3. An overview of the different tools that support the SharedHeart approach.

Typically the supervised rehabilitation program takes about three months. Joint goal setting with patients, discussing progress and frequent encouragement from caregivers are important factors facilitating continuation in CR programs [20]. However, physiotherapists have many patients to supervise. Both the patients and the physiotherapists would benefit from SDM tools that retain efficiency, while increasing the quality and depth of their interaction during the encounters. Therefore, in line with the survey results, we propose to have one SDM encounter every week for the first half of the supervised rehabilitation and then decrease this to one SDM encounter every two weeks. The gradual decrease in control by the physiotherapists shifts the responsibility gradually to the patient. In this way, when the patient finishes rehabilitation in the center, the currently best fitted exercise plan for the patient has been found and the patient is ready to take the full responsibility to maintain physical fitness. By following this SDM approach, our aim is to teach patients the skills for planning their physical activity, and to build strong habits during phase II of rehabilitation, that they will continue in phase III to foster long-term adherence.

In the SharedHeart approach, we integrated digital tools of the different *categories* proposed by Bonneux et al. [5]. Before the first SDM encounter, patients use a *preference elicitation application* to indicate their preferences and physiotherapists use a *clinical decision support system* to prepare for the encounter. In the encounters, patients and their physiotherapists create a personalized exercise plan for the patient with the aid of a *SDM tool that provides data and recommendations to foster communication and deliberation and guides the stakeholders through the SDM process*. Between encounters, patients use a *mobile tool providing decision support at home* and the physiotherapists use a *tool for remote follow-up*. Figure 3 gives an overview of the proposed SharedHeart approach and supporting digital applications.

3.2 Approach During a Single Encounter

At the start of the supervised rehabilitation, all information needed for shared decision making needs to be collected. From the patient's side, we need to assess his/her sports preferences, current situation (e.g. home and work situation), and physical limitations (e.g. pain or balance problems). To relieve the burden for physiotherapists, patients can indicate their preferences in the IPrefer tablet application in the waiting room. From a clinical point of view, we need the patient's latest clinical data (e.g. physiological parameters and results of cardiopulmonary exercise testing) and a tailored exercise prescription conforming to the evidence-based guidelines for physical activity. To support physiotherapists in making a guideline-based exercise prescription for the patient, we integrated the EXPERT tool [12, 13], i.e. a clinical decision support system that suggests a personalized, guideline-based exercise prescription for a patient, into the SharedHeart caregiver dashboard.

In the encounters, patients and their guiding physiotherapists discuss the patient's preferences for physical activity and collaboratively construct an exercise plan for the upcoming week in the SharedHeart caregiver dashboard. To

stimulate discussion and encourage exploration of new physical activities, the SDM tool provides guidance in creating the exercise plan by suggesting activities that comply with the clinical evidence on exercise effectiveness and the patient's sports preferences. At the end of each encounter, the patient goes home with a tailor-made, achievable exercise plan for next week.

Between encounters, the patient tries to adhere to the exercise plan. Encouraging health-promoting lifestyle change requires interventions that are integrated into daily life and provide support when and where people make decisions [17]. Therefore, we developed a mobile, persuasive telerehabilitation application that motivates patients to exercise and enables them to follow up on their exercise plan that was prepared in the SDM setting. Physiotherapists can also remotely follow up on the data that their patients collect in the SharedHeart caregiver dashboard.

One or two weeks after the previous SDM encounter, the patient has a new SDM encounter with the physiotherapist in which they discuss how the patient experienced the past days (e.g. How active was the patient? Did the patient adhere to the program?). This discussion is supported by the SharedHeart caregiver dashboard that visualizes the data collected in the patient mobile application. Based on the patient's recent performance and updated preferences and constraints, the exercise prescription is adapted and the plan for next week is constructed. This process repeats until the currently best fitting exercise prescription and exercise plan for the patient have been found.

4 The Design of the SharedHeart Platform

The SharedHeart digital platform augments the proposed SDM approach. In this section, we discuss the design of these applications and we highlight their contribution to shared decision making. The SharedHeart caregiver dashboard is the main application (as depicted in Fig. 3), supporting SDM during the encounters between the physiotherapist and the patient. The caregiver dashboard offers support in collaboratively setting exercise targets, creating an exercise plan and discussing progress. In the application, we applied the seven *principles* of Bonneux et al. [6] for the design of SDM tools for health behaviour change. In the context of our application, the behaviour change goal is being more physically active. The design principles of Bonneux et al. are depicted in *italics*. Next to using the caregiver dashboard during the SDM encounter, physiotherapists can also use it to prepare for their next encounter with the patient and to follow up on the patient's progress between visits. The IPrefer tablet application supports the preference elicitation before the first consultation, whereas the SharedHeart mobile application supports the patient in following up on the decisions that were made during the encounter.

4.1 Goal-Setting for Physical Activity

A key aspect in shared decision making for health behaviour change is *encouraging collaborative goal-setting*. In the context of physical activity for cardiac

rehabilitation, the goal can be expressed as an exercise prescription. Physiotherapists can use the EXPERT tool [12, 13] to generate a personalized exercise prescription for their patients. An example of a typical exercise prescription for a patient is as follows: “exercise at moderate intensity 3 to 5 times a week for 20 to 60 min per session and for at least 24 weeks”. Prior to the first SDM encounter, the physiotherapist prepares the initial exercise prescription for the patient using the EXPERT tool. This exercise prescription is discussed with the patient during the encounter. The EXPERT tool often defines ranges in the exercise prescription (e.g. 20–60 min of physical activity for 3–5 times per week). These can be discussed with the patient to come to a feasible exercise prescription for the patient. Furthermore, it is possible that the exercise prescription is too hard and thus not feasible for the patient at a certain point in the rehabilitation program. In this case, the physiotherapist can update the exercise prescription during the SDM encounter. In the follow-up encounters, the exercise prescription can be updated based on the patient’s progress and changes in risk profile, to make it more challenging for the patient.

The patient’s current status (e.g. most recent parameter values and physical fitness) is shown in the risk profile bar in the SharedHeart caregiver dashboard and the target situation is represented by the patient’s exercise prescription. As such, the design principle of Bonneux et al. [6] *give an overview of the current status, the target situation, and the available options* is met, but not combined into a comprehensive overview. As the available options, we can consider the ranges of the exercise prescription but also the ways to achieve the exercise prescription (as discussed in Sect. 4.2).

4.2 Creating an Exercise Plan

Patients experience difficulties in translating a generic exercise prescription to a concrete exercise plan fitting their needs. Also, interpreting exercise targets is a challenge for a number of patients. Patients need support when making decisions in their daily life related to their health condition, but physiotherapists are often not able to perform this demanding task. Moreover, patients should be encouraged to do lifestyle physical activity (e.g. taking the stairs, gardening and cleaning), additional exercise or both on days that they do not attend cardiac rehabilitation sessions [3]. Supporting patients in performing physical activity on these days is essential [26]. It is not a trivial task for physiotherapists to include all these aspects in their daily practice. Therefore, we provide patients and physiotherapists *support in making an action plan*, by constructing and following up on a patient-tailored exercise plan that includes both the training sessions in the rehabilitation center and the physical activities that the patient performs at home, as depicted in the exercise plan (i.e. nr 3 in Fig. 4). The information that is difficult for patients to understand (e.g. the exercise prescription) and the preference-sensitive decisions that should be made (e.g. the exercise plan) are the central components of this SDM screen.

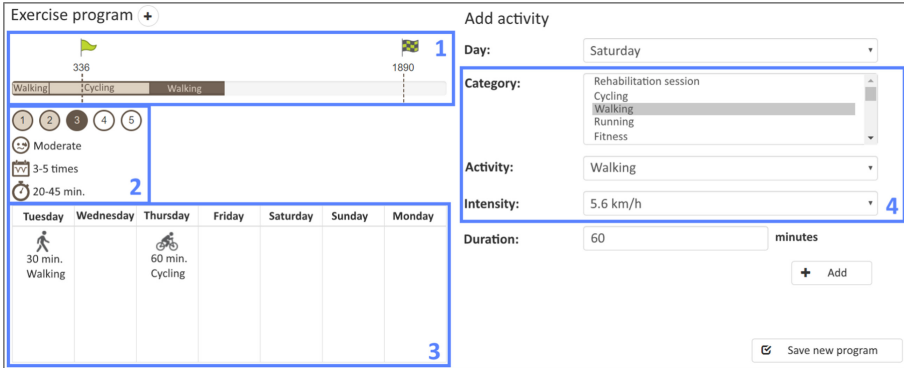


Fig. 4. During the SDM encounters, the patient and physiotherapist collaboratively construct an exercise plan by choosing activities (nr 4). The calendar view (nr 3) and patient-tailored progress bar (nr 1) provide an overview of respectively the plan and the associated progress towards the exercise targets. Also, the patient’s exercise prescription is shown (nr 2).

To foster discussion of the exercise plan and improve patient understanding of the exercise prescription and associated targets, we offer multiple complementary visualizations when constructing the exercise plan (Fig. 4). These visualizations were designed to encourage physiotherapists to collaboratively decide upon the patient’s physical activity. The exercise plan for the upcoming week is displayed in a weekly calendar (nr 3), which is a well-known representation format that can be easily understood by patients. In addition, the progress that will be made by the activities of the composed plan is visualized in a tailor-made progress bar (nr 1). The flags in the progress bar denote the personalized weekly exercise targets calculated based on the patient’s parameters and exercise prescription. To support patient understanding and encourage exploration of different activities, there is an indication of how much each activity contributes to achieving the targets, allowing the physiotherapist to *demonstrate the effects of behaviour change*. The overview of the patient’s prescription with an indication of how many training sessions will be completed by the composed plan (nr 2) links the exercise prescription to the exercise plan.

Research has demonstrated that patients prefer to choose their exercises from a range of exercise options [20]. Accordingly, the SharedHeart caregiver dashboard offers a patient-tailored list of recommended activity categories (nr 4) based on the patient’s ranking of sports activities as compiled in the IPrefer tablet application. For each activity category, multiple activities and variations are available (e.g. different speeds or intensities). For example, the category walking entails two specific activities: walking and Nordic walking. For each of these, there are different variations, including different walking speeds and conditions

(e.g. with a dog). The list of available categories, activities, and variations was constructed by selecting relevant activities from the Compendium of Physical Activities [1]. Since the focus of SharedHeart is on exercise training, no general lifestyle activities, such as cleaning and gardening, were included. To help physiotherapists and patients in choosing the appropriate variation (e.g. walking speed) for the patient, there is an indication of how well the specific activity variation matches with the patient's profile based on the patient's exercise prescription and the table of Vanhees et al. [29]. The recommendations for sports activities and intensities support the physiotherapist in *providing suggestions or tips* to the patient.

Next to the exercise prescription, the EXPERT tool offers patient-tailored safety advice to optimise medical safety of exercise training [12, 13]. The physiotherapists can use this advice to *provide suggestions or tips* on how to perform physical activity. In collaboration with an expert in exercise training for cardiac patients, we expanded these safety precautions with activity specific safety precautions and supplementary safety advice that can be provided based on the patient's physical limitations (pain and balance problems) that were collected in the IPrefer tablet application. During the SDM encounters, the physiotherapists can discuss the patient-tailored list of safety precautions with the patients to reduce their fear to exercise and improve their self-efficacy to perform exercise independently at home.

4.3 Reporting and Following Up on Physical Activity

The patient leaves the SDM encounter with a tailored exercise plan for the upcoming week. At home, patients use the SharedHeart mobile application to report and follow up on their physical activity (Fig. 5). The mobile application intends to keep the shared decision making process ongoing by giving cues of what was decided during the SDM encounter and offering supporting features to achieve the mutually agreed goals.

First of all, the application gives an overview of the patient's pre-constructed exercise plan that was made in the SDM setting and how well the patient adheres to it (Fig. 5A). Between encounters, patients can report which activities from the pre-constructed plan they perform and can follow up on their progress towards the weekly exercise targets in the progress visualization (Fig. 5B). Sometimes it is not possible to perform the planned activity, e.g. it is raining and the patient planned to go walking outside. When patients want to deviate from the exercise plan, they can add a new activity by selecting it from the list of recommended activities in the app, similarly as during the SDM encounter.

Cardiac patients should perform both exercise training and unstructured, lifestyle physical activity. The goal should be to carry out at least moderate intensity activities during the day (e.g. gardening, cleaning or vacuuming). At the end of the day, patients can report on their lifestyle physical activity (Fig. 5C). If the patient did not achieve the goal of at least moderate intensity activities, a tip to increase lifestyle physical activity is given. These tips are tailored to

the patient’s work and home situation (that was collected with the IPrefer application). Furthermore, patients can view the entire history of their self-reported physical activity in the mobile app.

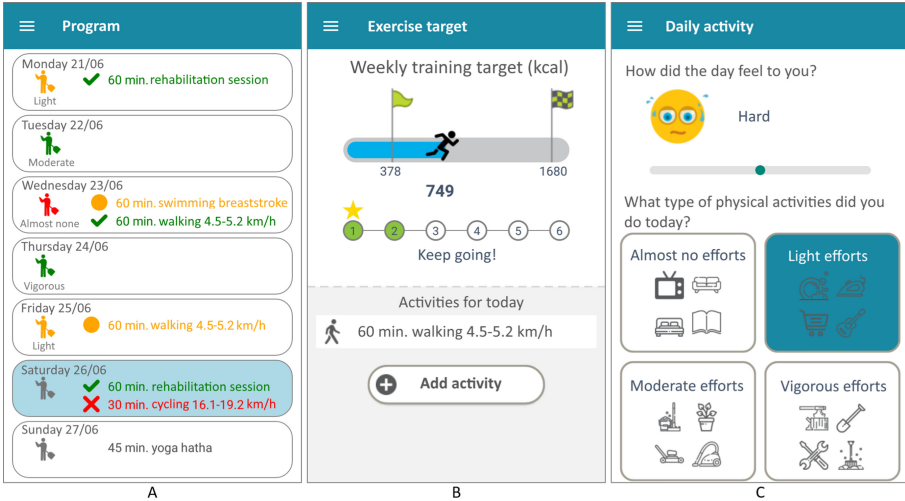
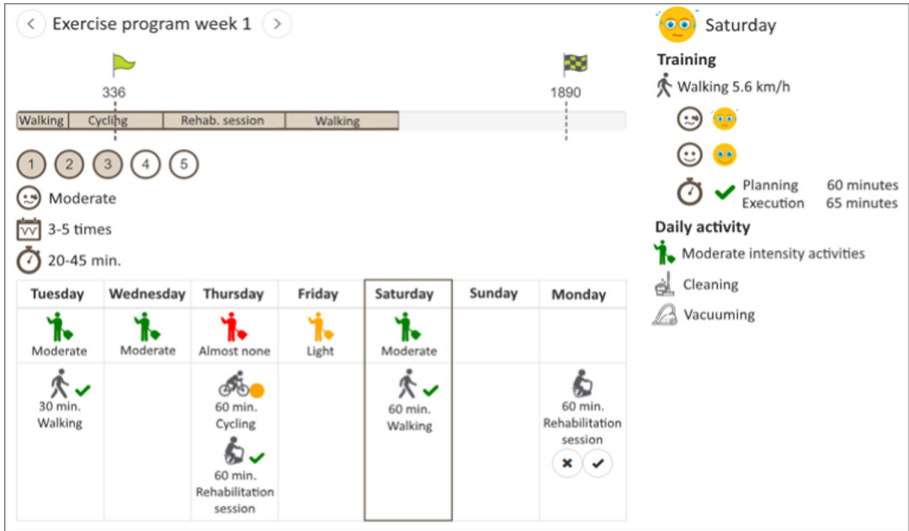


Fig. 5. During the week, patients can use the mobile application to A) follow up on their exercise plan, B) monitor their physical activity and C) report their daily activity.

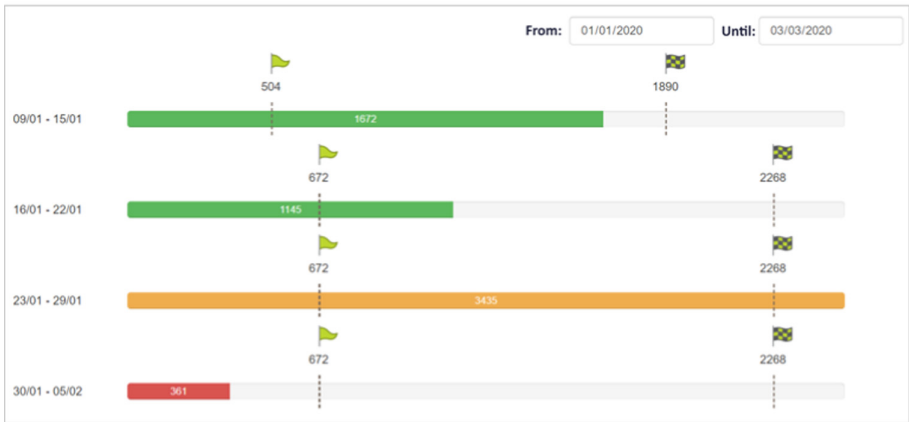
Patients need knowledge to be able to take part in shared decision making [16]. To improve patients’ knowledge and understanding of their condition, we offer short educational videos about cardiac rehabilitation in general and physical activity in particular. Moreover, we provide some videos tailored to the patient’s exercise plan. These videos provide tips and tricks for the specific activity categories incorporated in the exercise plan. We collaborated with an experienced physiotherapist to record videos for the most prevalent activity categories (i.e. walking, biking, fitness and racket sports). Watching an educational video can raise some questions. Patients can record these questions or other concerns in the notes, so they can discuss these issues in an upcoming appointment with their physiotherapist.

4.4 Discussing Performance of Physical Activity and Progress

All information that patients enter in the SharedHeart mobile application can be consulted by the physiotherapists in the caregiver dashboard (Fig. 6A). During the SDM encounter, the physiotherapist can use the caregiver dashboard to discuss how the patient performed last week. Optionally the physiotherapist can also follow up on the patient’s activity between encounters, but given the busy schedules of physiotherapists this is not mandatory for our proposed approach.



A



B

Fig. 6. During the SDM encounter, the patient’s exercise of the past week is discussed. A) The calendar overview indicates how the patient adhered to the constructed exercise plan. B) The progress bars show the patient’s long-term progress for physical activity.

In the discussion screen (Fig. 6A), we applied similar visualization techniques as in the construction screen (Fig. 4): a weekly calendar view and a tailor-made progress bar with exercise prescription and training sessions, both *enabling progress follow-up with visual elements* and supporting to *give feedback on performance*. The calendar view depicts the exercise plan that was constructed during the previous SDM encounter and how the patient adhered to it. The detailed information of an activity (e.g. time, tiredness, enjoyment) can be consulted as well. The progress bar shows how the activities that the patient

performed contributed to achieving the exercise targets. Whereas the activities' contribution to the targets was predicted when constructing the exercise plan (Fig. 4), the exact contribution of each performed activity is appraised during the SDM discussion (Fig. 6A). By demonstrating how the different activities contributed to achieving the exercise targets, the design principle *demonstrating the effects of behaviour change* is met. Feedback is provided by means of icons (e.g. reported activities), colors (e.g. adherence to the exercise plan) and visual indications (e.g. progress towards the exercise flags).

A more fine-grained application of the principle *overview of the patient's current status, the target situation and the available options* can be found in the weekly calendar overview with an indication of the patient's adherence to the exercise plan and the accompanying progress visualization. The current situation is the amount of physical activity that the patient already did in that week. The target situation is reaching the exercise targets (i.e. depicted by the flags). The available options are the different sports activities that the patient can perform to progress towards the exercise targets.

For patients, it is not always easy to understand how their health condition progresses over time. Therefore, it is very important to *enable progress follow-up with visual elements* and *give feedback on performance*. The evolution of the weekly exercise targets and the patient's achievement of these targets is depicted in Fig. 6B. Patients can see how their exercise targets (i.e. visualized by the flags) changed over time depending on their exercise capacity; a better exercise capacity results in adaptations to the exercise prescription and increases the associated exercise targets. Moreover, the long-term follow-up supports physiotherapists in making these adaptations to the exercise prescription and associated exercise targets.

Patients often think of topics they wanted to discuss right after an encounter [14]. We offer patients the possibility to take notes in the mobile app, so they can remember more easily what they want to discuss with their caregivers. The notes can be consulted in the SharedHeart caregiver dashboard. During the SDM encounter, the notes can be used to discuss the patient's concerns, and the physiotherapist can also consult the notes when preparing for the encounter.

5 Discussion

In phase II cardiac rehabilitation, the multiple-consultation model that is needed for shared decision making is in place [16]. Patients come several times a week to the rehabilitation center for their training sessions. In the SharedHeart approach, we combine these training sessions with SDM consultations to discuss the patient's physical activity. Given the busy schedules of physiotherapists and the number of patients that they have to supervise simultaneously, a balance should be made when deciding how often physiotherapists have SDM encounters with their patients. In our survey, most physiotherapists indicated that they preferred to have weekly or biweekly conversations with their patients about physical activity during the rehabilitation program. The proposed frequency of

the SharedHeart approach is in line with the physiotherapists' suggestion, i.e. weekly during the first 6 weeks and biweekly during the last 6 weeks of the rehabilitation program.

Our survey indicated that currently physiotherapists do shared decision making with patients for several topics, but the frequency is highly variant and there is still quite some room for improvement. This can be noticed by the discrepancies between physiotherapists' perceived usefulness of SDM (in Fig. 2) and the frequency that they currently perform it in their daily practice (in Fig. 1). Especially for the creation of a personalized exercise plan, there is still quite some room for improvement. The design of the SharedHeart platform revolves in particular around the follow-up of physical activity, with the personalized exercise plan as a key component. Furthermore, short- and long-term progress and goal-setting, which were considered as very useful for discussion, are the core components of the SharedHeart platform.

Based on physiotherapists' willingness to use a SDM tool to discuss physical activity with their patients, we expect that physiotherapists are willing to use the SharedHeart platform. However, when conducting the survey, we only involved physiotherapists of one rehabilitation center. Also, we did not explain the intended SharedHeart approach nor showed a similar platform supporting SDM to the physiotherapists, to prevent that they have a specific system in mind when filling in the survey. To bridge this gap, we plan to perform usability tests with patients and physiotherapists to explore the usability of the SharedHeart platform, and their opinion about the tools. As a next step, it should be investigated what are the effects of the SharedHeart approach. We submitted a protocol (NCT05026957) and received ethical approval from the medical ethical committees of Hasselt University and Jessa Hospital to perform a randomized, controlled clinical trial (RCT) preceded by a usability study. In the RCT, 80 coronary artery disease patients will be recruited to evaluate the impact of our proposed SharedHeart approach on patients' quality of life, exercise capacity, motivation to exercise, perception of rehabilitation, and engagement in the decision making process.

6 Conclusion

In this paper, we presented SharedHeart, a technology-supported shared decision making approach for physical activity in cardiac rehabilitation. In a survey, we investigated physiotherapists' current practice of SDM and their perceived usefulness of SDM and using SDM tools to discuss physical activity during phase II CR. Next, we described the SharedHeart approach and illustrated the design of the SharedHeart platform by demonstrating how the seven guidelines for SDM tools for behaviour change of Bonneux et al. [6] were applied in the SharedHeart caregiver dashboard.

Our proposed SharedHeart approach and accompanying applications focus only on SDM for physical activity. However, cardiac rehabilitation is a comprehensive program composed of several key components, including education,

nutrition counseling, physical activity, smoking cessation, stress management and medication intake [22]. For all components of the CR program that include a behaviour change, shared decision making can be a good way to increase patient motivation and involvement. With our work, we hope to provide other researchers an example of what a technology-supported SDM approach can look like and how an accompanying SDM tool can be designed. We hope that our current research provides a starting point for investigating SDM in telerehabilitation solutions to cope with the current challenges faced in cardiac rehabilitation and inspires other researchers in investigating technology-supported shared decision making for preference-sensitive decisions in diverse patient populations.

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