

# Design of an mHealth Application for Optimizing Preoperative Physical Function

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## ABSTRACT

This limited physical reserve capacity in older people might be a risk factor for further functional decline and complications after surgery. Shorter time between diagnosis and cancer surgery has made it more important to focus on effects of a short exercise program with high intensity and frequency. Studies have shown that patients with cancer need personalized support to perform preoperative exercises and that they prefer to do it at home or close to home. This work describes the development of a digital application consisting of exercises, feedback on performance, support, and motivational features.

**Keywords:** mHealth, Digital health, Preoperative physical activity

## INTRODUCTION

Due to improved and less invasive surgical treatment alternatives, older people undergo cancer surgery to a higher extent today. Moreover, the limited physical reserve capacity in older people might be a risk factor for further functional decline and complications after surgery (Griffiths et al., 2014). Since chronological age has been recognized as less important, the complexity in older peoples' health and physical function is more in focus today (Lin et al., 2016). A shift in cancer care in Sweden toward standardized and enhanced care processes, has led to that time between diagnosis and treatment (i.e., surgery) has been shortened. Thus, a period of three weeks is set as a standard for colorectal and liver surgery. Therefore, it has become important to focus on the effects of a short exercise program with high intensity and frequency.

Recent qualitative studies have shown that patients with cancer need personalized support to perform preoperative exercises and that they prefer to do it at home or close to home (Beck et al., 2020; Karlsson et al., 2020). Therefore, developing tools for personalized support is of utmost importance. Based on current research on web-based interventions of cancer survivors, the importance of a design that is tailored to the patient's needs has been highlighted (Corbett et al., 2018). It should be delivered at the right stage in the cancer trajectory and emphasize user involvement in the developmental phase. Goal

setting, performance feedback, self-monitoring and reminders are all known facilitators for motivation and adherence to physical activity interventions (Locke and Latham, 2002; Michie et al., 2011). These components are well suited for a digital tool to optimize and personalize the preoperative exercises, and previous research has found that mHealth solutions are well perceived by older adults if the technology is easy to use and does not replace personal interactions (Matson et al., 2018).

## **DEVELOPING AN APPLICATION FOR PREOPERATIVE TRAINING**

In a previous study, physiotherapists visited patients in their homes and supported them in conducting physical exercises during their preoperative phase. In the next step we developed a digital application consisting of, among other things, exercises, support, and motivational features.

The detailed features of the application were defined together with users during a co-creation process in workshops. Two workshops were conducted together with five patients. During the first workshop the participants discussed experiences from the previous intervention, factors they deemed relevant for adhering to the protocol and motivational aspects. During the second workshop the participants gave input on features and functionalities. One workshop was held together with five physiotherapists. In these workshops, experiences with the previous intervention, support needed for the patients and functionalities and interface for remote support were discussed. Further meetings and workshops were also conducted iteratively during the development phase.

## **VALUES AND IMPORTANT FEATURES TO INCLUDE IN THE APPLICATION**

The outcome of the three workshops could be divided into four categories. One was on a high level consisting of important values to consider when developing a tool like this. Two were related to functionalities to include, one with functionalities to include in this application for preoperative training and one category for functionalities that could be included in an extended version that also would support postoperative training. The last category consisted of important aspects to consider regarding interaction with the application.

### **Important Values to Consider**

The patients described the exercise program as an important break during a period in life that was chaotic due to the recently received diagnosis. They also pointed out that it was important to feel that you have done everything that you can do to gain the best possible output of the surgery. Knowledge and experience of the physiotherapist was also mentioned as important, and continuity with the same physiotherapist during the entire exercise program.

### **Functionalities to Include for the Preoperative Training**

Functionalities suggested for the preoperative training application were possibilities to communicate with the physiotherapist and to be able to use

video communication. The patients also wanted to be able to book meetings and follow-ups with the physiotherapist. Further, the patients suggested instruction videos with an instructor or a character that they could identify with.

With respect to the exercises, the patients wanted a clear overview of what should be done and when. The physiotherapists expressed a need for having database of exercises to choose from and the importance of easy access without being forced to switch between different applications.

Direct feedback was described as useful since it could give you information about if an exercise was performed correct without risk of getting injured. The possibility to be able to follow what has been done and what is left to do was described as useful. However, reminders about what is left to do needs to be given in a positive manner. Support and encouragement could be given when the exercise program has been well performed, but general encouragement and support was also mentioned as meaningful feedback. However, functionalities like that must be optional and different individuals need different kinds of encouragement. Further, the patients discussed possibilities to set both short-term and long-term goals, and possibilities to get feedback on progress. Being able to show progress to people around you was also mentioned as an advantage. The possibility to being able to follow what has been achieved and how the different training occasions have been perceived through self-ratings was described as valuable. Self-monitoring in terms of a training diary could be useful. However, it must be possible to skip this if you do not want to fill this in after every time you have conducted the exercise program.

In general, the importance of personalization was brought up, both with respect to which extent the preoperative training is digital vs physical together with a physiotherapist and with respect to how the exercise programs are designed. Personalization was also described as important regarding interaction with the application and with respect to how information is visualized.

In the workshops with the physiotherapists, it was discussed how the gathered data could be used. It was suggested that the data could be used as a basis for increasing the level of the exercises. Further, the gathered data could be used in the discussion/follow-up between the patient and the physiotherapist. Data from sensors could be used to provide the patient with real-time feedback, both in terms of achievement and if an exercise has been correct conducted.

Inclusion of general information was discussed in terms placing the preoperative training in a larger context. Explanations about why physical activity in general are important, but also why you have received this training program. The information package could also consist of information about healthy food and risks related to smoking and alcohol.

### **Functionalities to Include for the Postoperative Training**

In the workshops it was also discussed how the application could be used later for postoperative training as well. In this discussion the patients suggested possibilities to support a lifestyle change and to be able to set long term

goals. For a more long-term usage, social functionalities were suggested. This in terms of being able to use the technology to communicate with other people in the same situation and to be able to conduct exercises together. Suggestions for different activities and getting in touch with other patients living nearby was also mentioned as possible functionalities. Finally, the patients suggested the possibility to be able to include relatives in the usage so that they could support and encourage. However, it was pointed out that all these functionalities must be optional and possible to set depending on what kind of person you are.

### **Interaction With the Application**

With respect to interaction with the application the patients pointed out the need for large text and clear pictures. There should not be too much text and the text should be easy to understand and not consist of complicated technical expressions. If the system uses additional devices and/or sensors, these should be easy to put on and use.

## **CONTENT AND INTERACTION WITH THE APPLICATION**

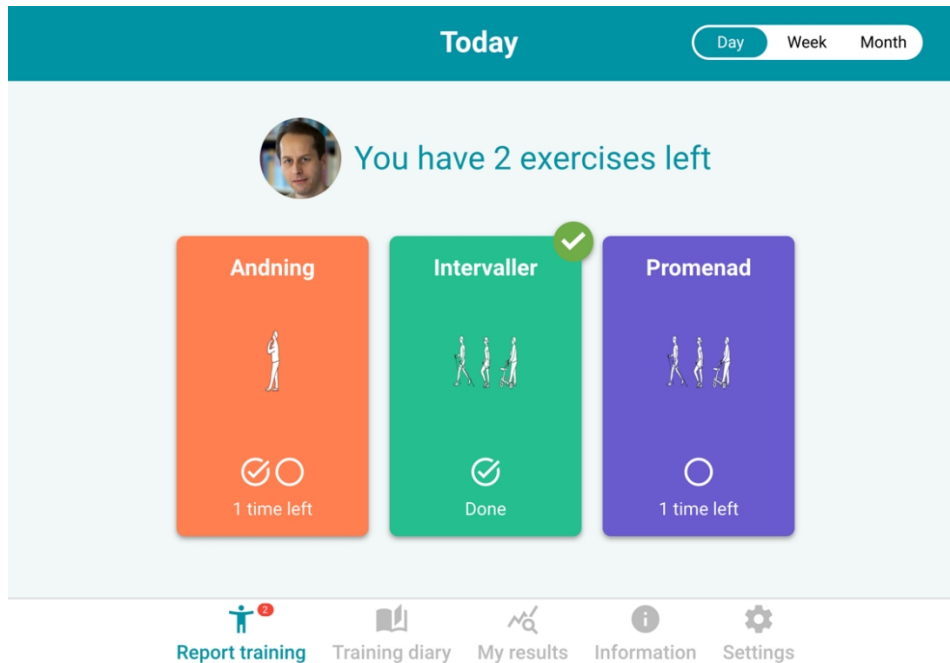
The application system consists of two separate end user applications, one web application for physiotherapists, and one mobile (tablet) application for patients. The system also includes a backend where data about e.g., accounts, patients and exercises are saved.

### **The Patient Application**

The patient application allows patients to see which exercises they are supposed to do each day, and to report to which extent the exercises have been completed. Exercises are represented by colored cards (Figure 1), showing the name of the exercise and how many times it should be performed on a particular day. The cards are updated as exercises are reported, and there is also a textual message that summarizes how many daily exercises are left to be completed. This makes it easy for the patients to keep track of their daily training status and what is still left to do, e.g., if they start and quit the application several times each day.

By clicking an exercise card, the patient is presented with more detailed exercise settings, specifying exactly how the exercise should be performed the current day. This may include the number of sets and repetitions, duration, intensity, and so on, depending on the type of the exercise. The patient also has access to general instructions on how the exercise should be performed, which may be shown as a combination of text, images and even videos.

After reading the settings, and possibly looking at the instructions, the patient performs the exercise without help from the application. We plan to add support for exercise support or guidance in future versions, but currently patients have to perform the exercises on their own. Later, when the patient is finished, they go back to the application and report that the exercise is completed. This can be done at any time, and even on a different day, to make it as convenient for the patient as possible. During reporting, the application



**Figure 1:** The patient app showing (three) coloured cards representing exercises to be performed.

will ask the patient to input data about when and how the exercise was performed (e.g., time of day, number of sets and repetitions, etc.), and how the patient experienced the exertion level. The reported data is then uploaded to the system's backend and saved in a database.

All reported exercise data are automatically gathered in a training diary section of the application, giving the patient access to the whole training history for later inspection. The diary is a log of training related events (e.g., reported exercises) which is populated automatically as the patient is following their training program over time. The diary lists entries (events) per day in a chronological order (see Figure 2). The patients can also make notes in the diary if they like, i.e., explaining for instance how they felt on a particular day or if they had problems performing an exercise. The diary content is accessible to the physiotherapist, who is also able to give likes (thumbs up) or comment on individual diary entries, as a way of giving feedback to the patient.

The patients can follow their training progress in several ways. The daily report section (Figure 1) is focused on the daily progress, while the diary also provides a historical view on the progress in the past. There is also a results section where progress graphs are used to visualize the progress (e.g., the percentage of completed exercises or reported exercise parameter values) in an overview fashion, see example in Figure 3. On this page the patient can also see a textual feedback message that summarizes their progress the last few days in an easy-to-understand manner. This message is generated automatically by the application, based on the patient's results, but is presented

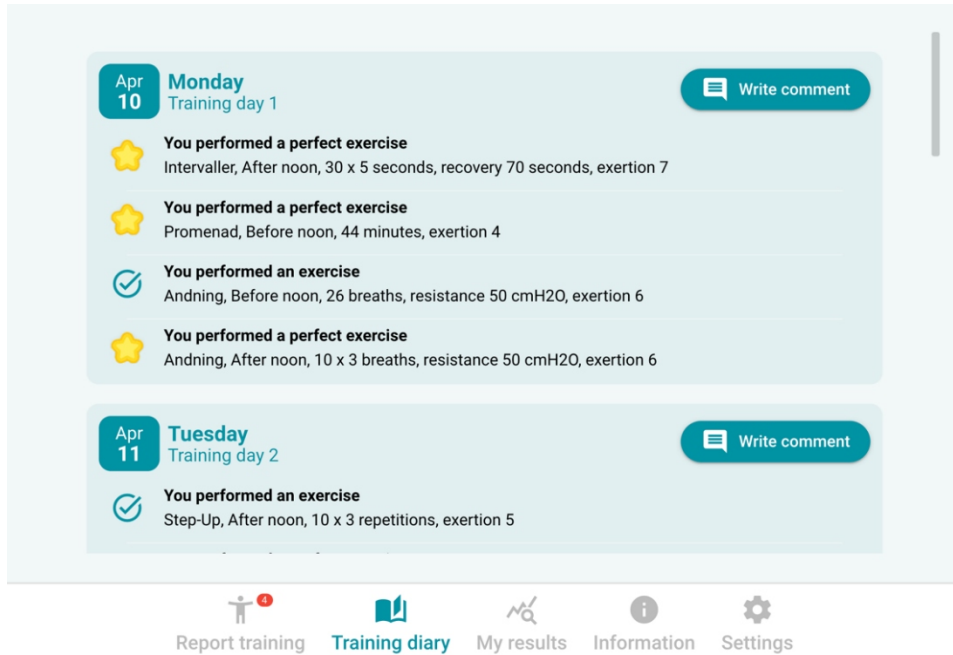


Figure 2: The patient’s training diary.



Figure 3: The patient application result section.

next to an image of the physiotherapist to give the impression that it originates from him or her. This is to make the message more personal and to keep the connection between the patient and physiotherapist strong, something that was requested in meetings with user groups. Ideally the message should

have been written by the physiotherapist, but as they often have limited time to give feedback in the system, we choose to use these kinds of auto-generated messages instead.

The patient application includes features for supporting and increasing the motivation to conduct the exercises. For example, rewards in the form of medals are given based on how well the patient follows the exercise program, both in terms how many exercises the patient reports, but also how well they follow the settings of each exercise, e.g., the assigned number of repetitions or time duration. The patient can see their medals on the result section in the application (Figure 3), and information about acquired medals is also automatically logged in the training diary. The liking or commenting on diary entries by the physiotherapist can also increase the patient's motivation as it can create a sense one's efforts being acknowledged and appreciated by someone else. This kind of social features could be extended even further, to allow for instance patients to, if they wish, making their diaries available also to friends and family, and even other patients. In addition to medals and social feedback, the app also provides an information section where patients read about for example why preoperative training is important, to further strengthen the motivation to follow the exercise program.

### The Physiotherapist Application

The physiotherapist application allows physiotherapists to create individualized training programs for their patients, and then to monitor the progress of those patients as they start performing their exercises.

When creating a training program for a particular patient, the physiotherapist first selects which exercises to include from an exercise library. The physiotherapist then adjusts the settings of each exercise, to suit the patient's needs and abilities. Depending on the exercise type, this may include on which weekdays the exercise should be performed, how many times per day, the recommended exertion level, number of repetitions, duration, and so on (see Figure 4). Once the physiotherapist is done, the exercise program can be saved and uploaded to the backend, thus making it active for the patient.

Current training program  
Created by Lars Lärka, active from 2023/04/10

Arbning	Mo Tu We Th Fr Sa Su	Weekdays	2	Per day	5-7	Exertion	30	Breaths	50 cmH2O	Resistance
Intervaller	Mo -- -- Th -- -- Su	Weekdays	1	Per day	6-8	Exertion	30 x 5	Intervals	60 sec	Recovery
Promenad	Mo Tu We Th Fr Sa Su	Weekdays	1	Per day	3-4	Exertion	30 min	Duration		
StepUp	-- Tu -- -- Fr -- --	Weekdays	1	Per day	6-8	Exertion	12 x 3	Steps	0 kg	Weight belt
Uppskräppigt	-- We -- -- Sa -- --	Weekdays	1	Per day	6-8	Exertion	8 x 3	Standups	50 cm	Elevation
									0 kg	Weight belt

Modify training program

No earlier versions

**Figure 4:** The training program of a patient, each row represents a particular exercise with settings that can be adjusted individually.

As patients use their tablet app to report completed exercises, the physiotherapist can monitor the results. A results page makes it possible to see, for each exercise type, graphs showing reported data for different exercise parameters (e.g., exertion reported by the patient). Based on the reported data, the physiotherapist can then determine whether it seems that the patient is able to perform the exercises as intended, or if some exercise settings need to be adjusted. Adjustment of the exercise program can be done by selecting an exercise row (Figure 5) and then entering new values for one or several parameters. It's also possible to add new exercises, or even to remove existing ones entirely. Saving the updated program will upload a new version to the backend, which will then be available for the patient on the following day.

The physiotherapist also has access to the patient's training diary (Figure 6). As the diary lists entries (events) per day in a chronological order, it allows the physiotherapist to get a more day centric view of the patient's progress (what happened on a particular day), compared to the results page. The diary page also allows the physiotherapist to give feedback to the patient, e.g., by "liking" entries (give a thumbs up) or by writing comments. Such feedback is immediately visible to the patient in their training diary and may be a motivator for the patient to keep up their training.

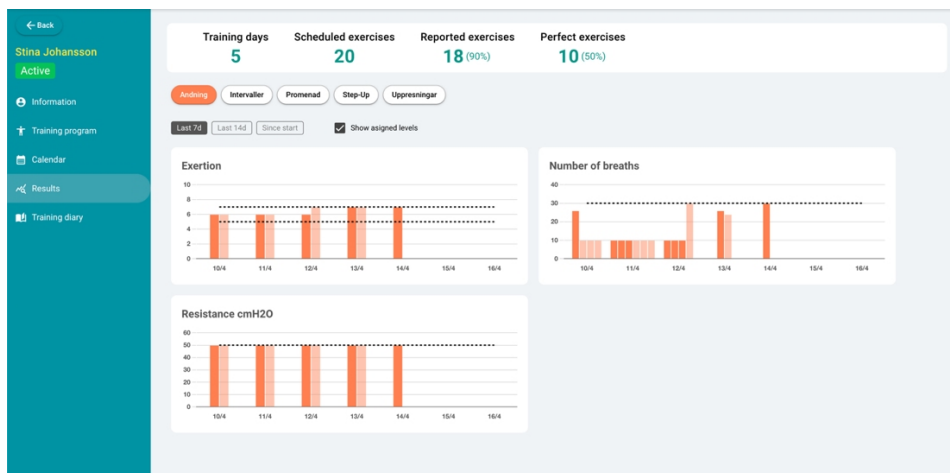


Figure 5: Various graphs showing a patient's reported data for a particular exercise.

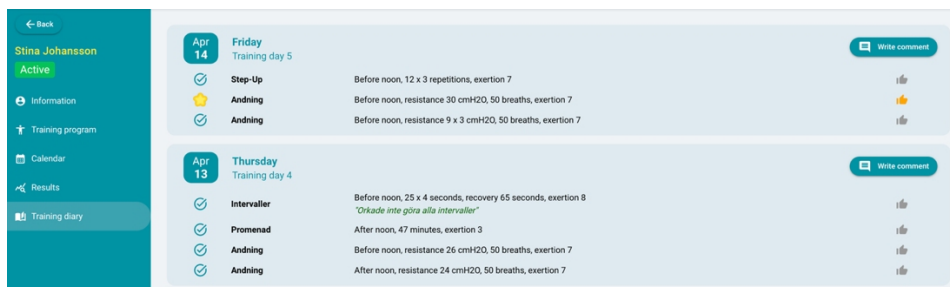


Figure 6: The physiotherapist view of the patient's training diary.



## DISCUSSION AND CONCLUSION

The development of the described application is an ongoing work, however based on the initial collaboration with the patients some insights have been made. One important motivational aspect that was pointed out by the patients was that it could contribute to the feeling of having done everything that you can do to gain the best possible output of the surgery. The importance of personalization was described as important. On a high level it was discussed with respect to which extent the preoperative training should be digital or physical together with a physiotherapist. Further, possibilities with making the exercise programs personalized was pointed out by the patients. Finally, interaction with the application and with respect to how information is visualized was also described as an important aspect of the personalization. However, there are several parameters related to each exercise that must be gathered and visualized. This in turn makes it even more important with a clear and easy interaction with the application.

In the forthcoming work, the project will continue to develop the application together with the patients, and as a final step of the project effects on postoperative complications and postoperative recovery will be evaluated.

## ACKNOWLEDGMENT

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