University of Toronto

Final Report

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myACL

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1 Goal & Motivation

1.1 Background

One of the four ligaments of the knee called the anterior cruciate ligament (ACL) is commonly torn during sports and physical activity. Approximately 150,000 people tear this ligament annually (in US), of which 100,000 people undergo a surgery to reconstruct this ligament. The hamstring tendon or the patellar tendon are commonly used to replace the torn ACL. The rehabilitation process following this surgery lasts 6-8 months. After surgery patients often receive a few pieces of paper from their surgeon detailing their rehabilitation protocol. Typically patients present their protocol to a physical therapist who helps the patient through the rehabilitation process. The therapist uses the protocol as a guideline and aids the patient to regain their knee mobility, strength and prior level of function.

1.2 Motivation

The post-operative rehabilitation following ACL reconstruction lasts 6-8 months and costs approximately $3500-4000 in Canada. Due to these factors patient compliance is often poor and can result in the patient not returning to their prior level of sports and physical activity.

1.2.1 Current Process

An ACL reconstruction lasts a few hours and the patient is then sent home with medication, crutches, a brace and some written instructions for what they need to do for the next 6-8 months. This can be very overwhelming and difficult to manage as a patient. The patient also relies entirely on their physical therapist or surgeon to indicate to them their level of progress and has no method of tracking their own functional recovery.

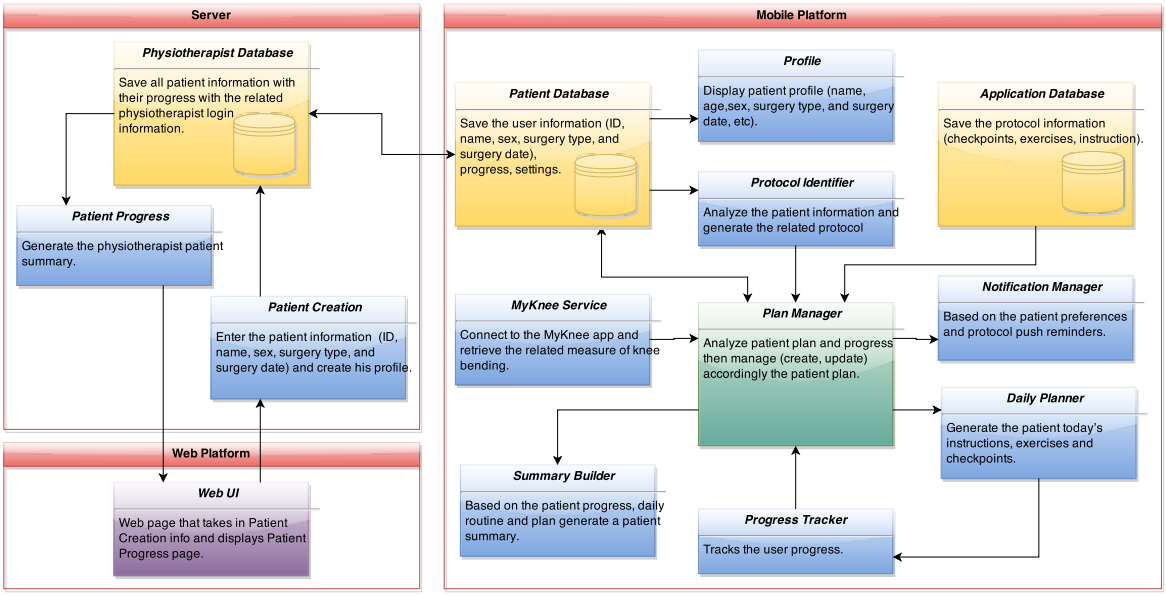
1.2.2 Proposed Process

The motivation behind our app is to enhance this rehabilitation journey by taking a patient centered approach. Rehabilitation following ACL reconstruction would be improved by providing the patient with a mobile app that allows them to see their current and relative state in their personal rehabilitation protocol. The goal is to improve patient compliance with their post-operative care and increase the chances of patients returning to their pre-injury level of physical activity and sport.

This app will also address a major gap in accessibility for those patients who undergo the surgery but cannot afford the post-operative rehabilitation expenses. In the latter situation the app cannot replace a physical therapist but it can provide some guidance to a patient who may not be receiving any post-operative care.

2 Overall Design

2.1 Block Diagram



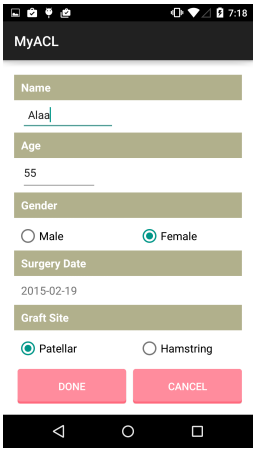
2.2 Application Workflow

- The patient will create the their profile, filling in their basic information including their surgery date and type.
  - The system will generate a unique ID for the patient.
  - The **Protocol Identifier** will choose the appropriate protocol.
  - The **Plan Manager** will generate and create the patient overall plan.
- The **Summary builder** will create:
  - A home screen with a summary of today's progress and routine.
  - An over all progress to date (graphically).
- The **Daily Planner** will fetch the daily checklist that has to be done for today.
- The **Progress Tracker** will track the user progress and daily checklist. It will then push the info back to the **Plan manager** which accordingly updates the overall plan.
- The **Notification Manager** will remind the patient of his daily tasks (configure **Settings**).
- Exercises requiring knee bending measurements will connect to the **MyKnee** application and retrieve measurement data.
- Patient progress and profile will automatically sync to the web server's **Physiotherapist Database** for the physiotherapist to view.

3 Statement of Functionality & Screenshots from App

3.1 Create Profile

When the patient opens the application for the first time, a create profile screen will show up for the patient to fill in. Note: This will only show up once, upon first installation.



3.2 Generate Plan

Based on the Patient's profile, the application generates a 6-8 month plan. The deciding factors are, the surgery type (we currently support protocols for the patellar and hamstring tendon graft sites) and the surgery date (used to determine dates in the plan).

From the generated plan, we can display an overall summary. The patient has three views of the plan that range from an overall timeline down to the daily exercises

3.2.1 Timeline View

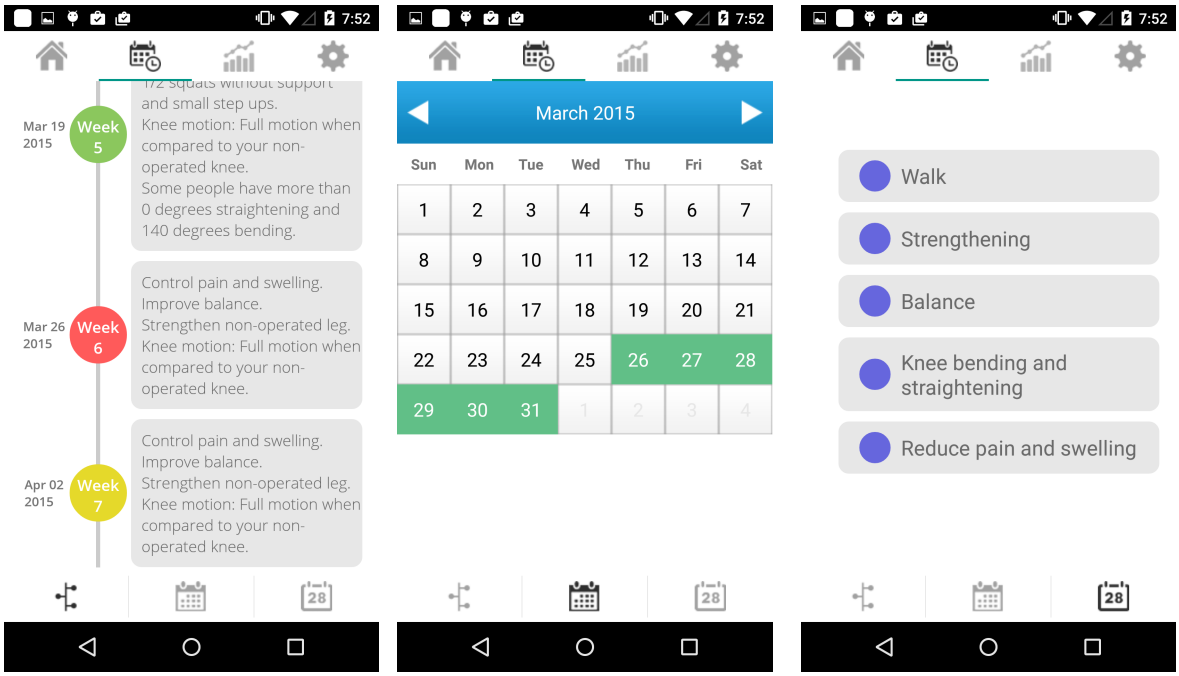
The patient will see the plan as a scrollable timeline. Each week corresponds to a milestone and indicates a start date as well as a list of goals to attain. The colour of each week represents a visual status (green = past, red = present, yellow = future). Clicking on the week will move to the calendar view.

3.2.2 Calendar View

The patient will see the plan as a monthly calendar and their current week will be highlighted. Clicking on a day will move to that day's view.

3.2.3 Day View

The patient will see a list of exercise categories that they need to complete that day. Clicking on a category, will open all the exercises they need to complete for that category.



(a) Timeline View (b) Calendar View (c) Day View

3.3 Home Summary

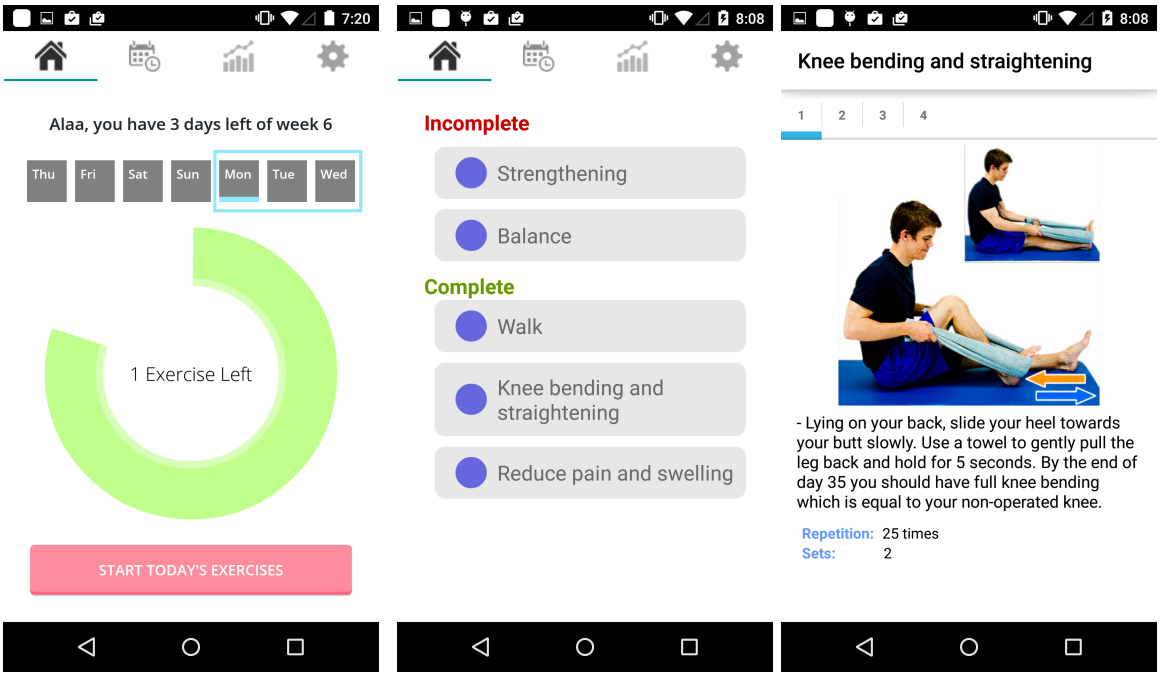
Each day a new daily summary is generated to be displayed on the home page. On startup, the patient will see the following:

- The number of days left in the current week.
- The current week number.
- The current day of the week.
- The number of exercises left for today (pie chart).

3.4 Today's Exercises

From home page, the user can click on a button that takes them to their *Today's Exercises*. This is a list of the categories of exercises they need to complete. The page also displays a list of categories that they have already completed that day. To move a category from one list to the other, the user can swipe the item away.

Clicking on a category will take the patient to the exercises in that category. To move between exercises, the patient can swipe through the numbered tabs. Each exercise may have steps, pictures, description, duration, sets and frequency values.

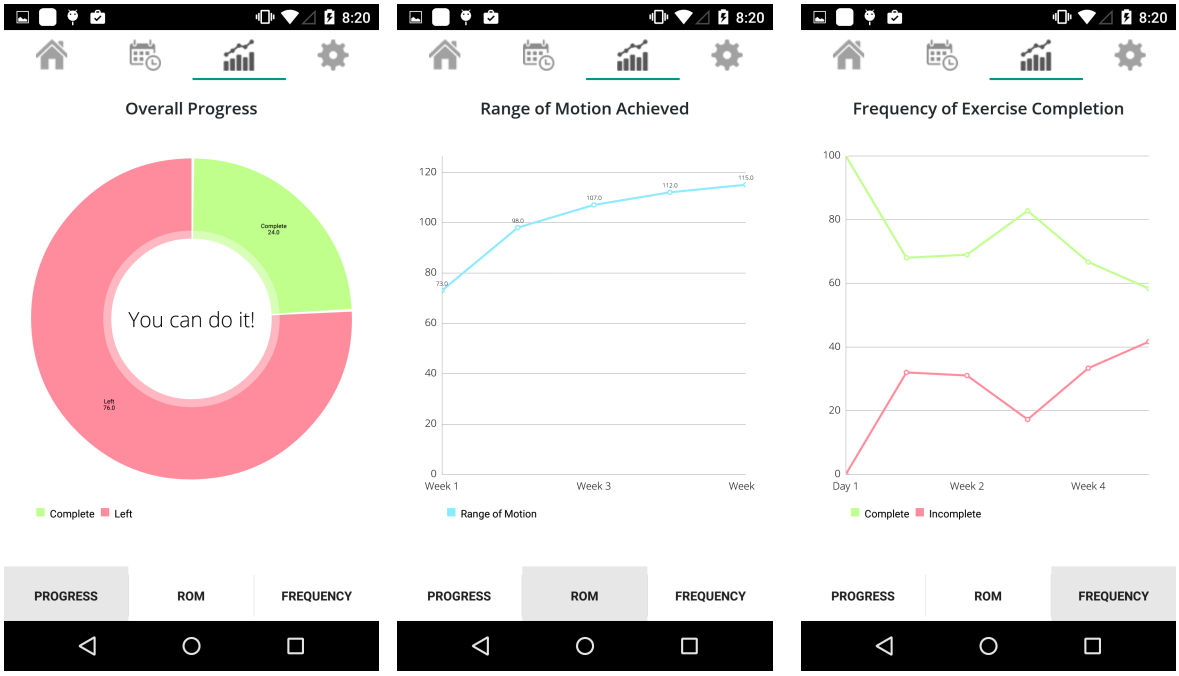


(a) Home Page (b) Today Plan (c) Exercises

3.5 Progress Tracking

Once categories are swiped completed, the progress tracker stores them in the plan (our database). Each day, the progress tracker sends an update of the patients status, to the server via REST call. In addition, the patient will be able to see their progress through three graphs.

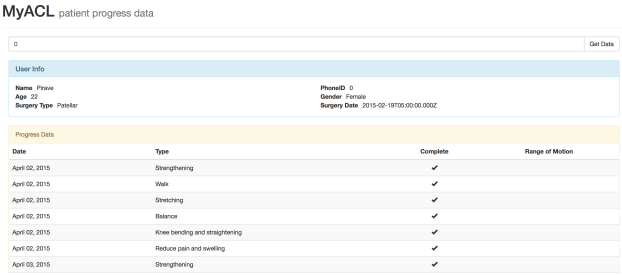
- How far along they are into their plan (pie chart).
- Their range of motion measurements retrieved through **MyKnee** (line graph).
- The frequency of completed exercises over a week (line graph).



3.6 REST Web Service & Physiotherapist View

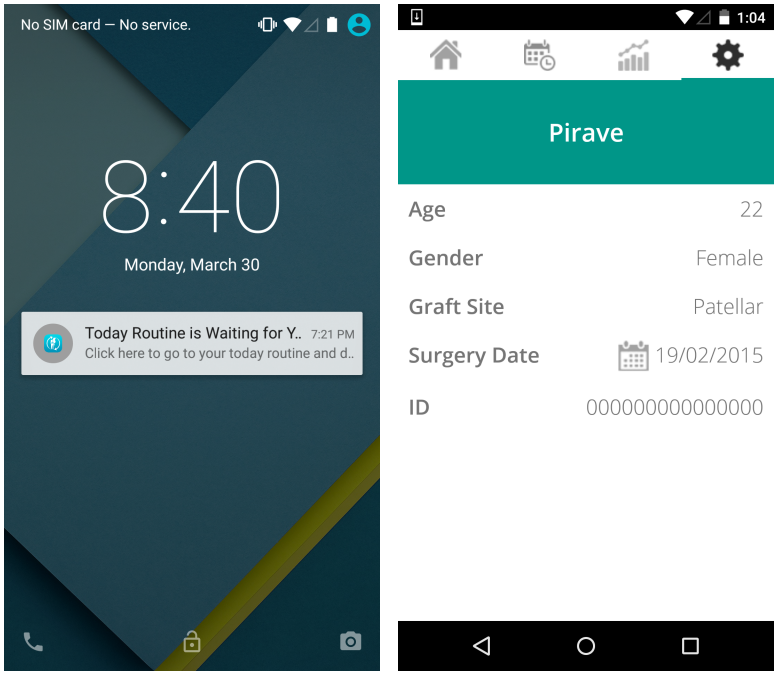
We have built a REST API on `node.js`. The app sends POST requests with data on the patient's profile (during creation) as well as the patient's daily progress.

Currently this API is open, and can be consumed by anyone. We have built a simple physiotherapist view that sends GET requests, and display patient data to the physiotherapist. Note: the physiotherapist needs the patients unique ID to retrieve their data.



3.7 Setting

Here the patient will able to turn notifications on or off. If a patient has completed all their daily exercises and/or has notifications turned off, they will not receive a reminder. This page also displays the user's profile. This is where the patient's unique ID is kept for easy access, when their physiotherapist requires it to track their progress.



(a) Reminders (b) Profile Page

3.8 Technical Specifications

Application Environment The application is built to work on android 17 OS.

Databases SQLite was used on the mobile platform. We used mongoDB as our server database.

External Libraries We used imported some libraries to get create a modern UI.

`MPAndroidChart`[1] To generate our graphs.

`ListViewAnimations`[2] To create our swiping effect.

Server Component We used the `node.js`[3] framework to build our web service.

We have currently deployed this web application on `heroku`'s[4] cloud platform.

[1] `https://github.com/PhilJay/MPAndroidChart`
[2] `http://nhaarman.github.io/ListViewAnimations/`
[3] `https://nodejs.org`
[4] `https://www.heroku.com`

4 What did we learn?

4.1 Programmers

4.1.1 Technical

From a technical perspective, we have come a long way in expanding our knowledge about web development. As discussed in the proposal, we were able to do research and produce an application that included,

- Server integration - we built a REST web service.
- Connecting to external apps - we connect to MyKnee, retrieve data and store it in our application.
- Sleek UI by Android Conventions - we believe our GUI is very user friendly and follows the android conventions.

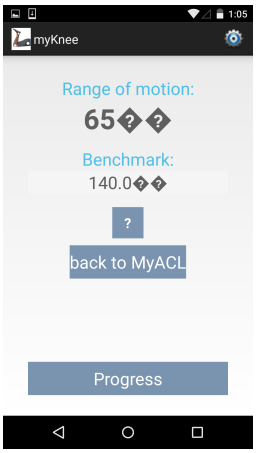


Figure 5: Returning back to MyACL after using MyKnee

4.1.2 Non-techinal

As programmers, it was quite difficult for us to understand the requirements from the apper. It was the first time we were asked to take someone else's vision and implement it. Over the course of our project we learnt to communicate effectively with our apper so that we did not interpret anything differently. Though we were able to eventually understand what our apper envisioned, it took more time to translate these requirements into a technical perspective, and evaluate whether they were feasible or not.

Apart from our application, we now have a deeper appreciation and understanding of the role of a physiotherapist. We hope our application will impact patients who have undergone an ACL surgery in a positive way. This sense of accomplishment has helped us see further into how technology can help in almost every aspect of life.

4.2 Apper

I learned a great deal about trying to come up with a consensus based on research and clinical experience when it comes to protocol design for post-operative care. I also learned from both programmers about user interface and functionality of mobile applications.

5 Member Contribution & Teamwork

5.1 Programmers

5.1.1 Division & Version Control

We used `github` as our source of version control to sync as well as keep track of our project. To divide the work, we started off at our block diagram. We looked at the components we wanted to complete for spiral one and divided them up evenly (based on difficulty). Each consecutive spiral was done in a similar fashion. We believe the modularity of our block diagram and application design, helped us in separating the work with minimal, if any, overlap. We made sure to keep in contact nearly every single day, which enabled us to stay focused, up to date and most importantly motivated.

5.1.2 Alaa Abdulaal

Alaa contributed to this project by forming the structure of the **Protocol Databases**. Since these databases held data pre-filled by our Apper, Alaa implemented the feature that would copy these external databases into our application. Alaa also generated the **Patient Database** that held the user's information, including the their progress. To interact with these databases she created the all the database handlers that the **Profile Manager** and the **Plan Manager** use. Doing so allowed us to modularize the code early on in our process, and ease database communications when needed further down. Apart from organizing the database infrastructure, Alaa did the research and made the changes to the **MyKnee** application in order for it to interact with our application. She was able to retrieve the data and store it into our patients database for tracking. The research and implementation of our **Notification Manager** was built by her. Finally the overall **UI** of the Mobile Application was designed and implemented by Alaa. She took inspiration from many similar applications (as seen in the **Home & Overall Summary views**, as well as guidelines proposed by our guest lecturers from *Plastics* (navigational standards).

5.1.3 Pirave Eahalaivan

Pirave contributed to this project by taking the information from the Profile Manager and creating a **Protocol Identifier** which generates a custom plan for the patient. She also designed

the infrastructure of the **Plan Manager** that stores this custom plan, and *gets* information in an object oriented form when needed. The Plan Manager talks to many other components including the **Daily Planner**, which she created to generate a daily routine based on the custom plan. Pirave was also responsible for the **Progress Tracker** which locally stores data as well as uses the **APIClient** to POST data back to our **Web Service** (which she created as well). Pirave also created a simple **Web UI** for the physiotherapist to GET and view this data in a more readable format. Finally, she took the locally stored progress information to generate graphical charts for our **Progress Summary Builder**.

5.2 Apper

5.2.1 Nirtal Shah

Nirtal's main contribution was to consolidate research, published surgical protocols and his own clinical experience to design two distinct ACL post-operative protocols that are the core of the content for this app. Additionally Nirtal contributed to the initial user interface of the app and collaborated with both programmers to determine the functionality of the app in a way that would be useful for patients.

6 Apper Context

This app has huge implications for the field of physical therapy and rehabilitation. By providing patients with a post-operative app it will change the way rehabilitation is delivered to patients. The existence of this app can help to improve patient compliance, can allow patients to track their own progress and ultimately improve patient outcomes. This would be a very patient centered approach since it puts the information and ability to track progress in the hands of the patient instead of the health care provider. This will also alter the patient-therapist relationship since the patient can now ask informed questions about their goals and progress instead of being a passive recipient of rehabilitation. It will also make the job of the therapist easier because they will be assisted with this guideline and they can modify aspects of it when appropriate for their patient. Lastly, this app addresses the gap in the access to rehabilitation services such as physiotherapy. There are people who undergo this surgery and have little to no guidance following their surgery. This app can fill that void and provide everyone with a guideline that is based on research and clinical experience.

7 Future Work

We hope to improve the infrastructure of our Web Service, so that it connects physiotherapists with their patients via a login. This will improve security and as well as be more convenient for the physiotherapist to use.

Another improvement would be to store the two protocol databases we use to generate the plan somewhere on the cloud. We only use one of the two databases, and that itself is only used once, during profile creation. Storing this on the cloud would allow us to ship our app in a lighter form.

Usability testing with patients who have undergone an ACL reconstruction. This will help us determine how the app functions and if there are any issues around usability. This process will also help to refine the protocol within the app.

Lastly, we hope to release the app in the Google Play Store so that it is available for patients who have undergone this surgery.

Word Count: 2455 (including Apper Context)