

myHipRehab: A Mobile Health App

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Abstract—myHipRehab is a companion app for patients who require rehabilitation after hip surgery. It works best for those who have undergone hip pinning surgery, which occurs after a hip fracture in the head of the femur area and uses a front and side incision around the joint. Following this procedure, patients must follow a physical therapy regimen to ensure proper healing and strengthening of the hip. The rehab phase of recovery has several challenges associated with it for both the patient and their provider, which include ensuring the patient sticks with the therapy regimen, measuring the patient's progress, and communicating whether or not the patient is performing exercises safely and correctly. myHipRehab addresses each of these challenges by instructing the patient through different hip exercises in real time. It stores the patient's progress and allows them to give feedback on their pain levels after each exercise. To encourage participation, the patient is rewarded with congratulatory graphics and trophies after completing each workout. This project was advised by Dr. Benjamin Gordon, an Applied Physiology and Kinesiology expert in the UF College of Human and Health Performance, and was completed for Dr. Sumi Helal's Digital Health course at the University of Florida.

Index Terms—Mobile Health Application, Mobile Health, mHealth, Action-Based Behavior Model, Physical Therapy, Hip Surgery

I. INTRODUCTION

- 1. Contextualization: The project is a Mobile Health (mHealth) application, meaning it is wireless technology used to collect data and administer medical care. The focus of the project is to make a comprehensive device that combines software development, design, and medical research to enhance a patient's experience recovering from hip surgery.
- 2. Problem: Hip fractures are a common health problem in older adults that can significantly disrupt their quality of life. Over 325,000 fractures happen annually in the United States, and many complications are associated with the injury [1]. In fact, about 1 in 3 patients die in the year following the fracture, and of those that live, many face a large and disabling reduction in mobility and joint function [2]. Mental health can also decline due to the pain of the recovery process. Since the aftermath of a hip fracture and surgery can be so severe, it is essential that proper rehab procedures are followed after any fracture that requires hip surgery. To help prevent the worst of these problems, it is important for patients to stay engaged throughout the physical therapy process. myHipRehab aims to help with this engagement by

increasing patient empowerment after hip surgery. It is expected that this increased empowerment could also lower mortality and disability rates and improve mental health following hip fracture.

- 3. Consequences (impacts): As shown by the volume of yearly hip fractures and the complications associated with them, mHealth technology that addresses recovery is in high demand. Patients may have access to conventional, in-person physical therapy, but it has downsides: co-pays, transportation to and from appointments, and finding a doctor who provides enough support and encouragement. On the other hand, simplistic recovery apps may allow patients to log their own exercise or pain levels, but they do not provide accurate or real-time feedback on patients' performance. Therefore, an app that combines real-time data collection with human-centered, friendly design could greatly improve the recovery process. In addition, with a large enough network of users, there would be potential to draw similarities between them to tailor their experiences. For example, if patients who did their exercises too fast were more at-risk for injury, the app could use artificial intelligence to recognize their pace and send them more warnings to slow down.
- 3.5. Related work: Other rehabilitation apps include a few similar features to myHipRehab. For example, the app PhysYou [3] and the Physical Therapy App [4] are both tools that allow doctors to provide a rehab regimen to patients in the form of a mobile app. The use of an app allows patients and doctors to access the exercises in a simple way. The app Patellr [5], provides another important rehab feature, in that it allows patients and doctors to track the patient's progress. While this allows the patients to input and see their progress, it does not provide any support for the accuracy of the exercises. Another app, Exerceo [6], uses visual tracking of poses to determine if patients are completing exercises accurately. This app, however, lacks the tracking of progress and exercises that PhysYou [3] and Physical Therapy App [4] target. myHipRehab, on the other hand, provides a combination of each of these features. It allows doctors to share a set exercise regiment and for patients to easily access it, and it also provides the use of a video camera so that patients can send their video recordings to doctors to ensure that the exercises are being completed accurately. In this manner it also leads to doctors and patients being

able to track progress. Our app will thus fit in well on the rehabilitation app market.

- 4. Proposed solution: The proposed solution is a mobile health app that walks the user through seven exercises for post-hip surgery rehabilitation. Each exercise has a corresponding GIF showing the user how to do the exercise, which can help with patient empowerment by clearly demonstrating the proper form that they need to follow. Additionally, the user is shown how many sets and repetitions to do, how long the rest period should be after the exercise, what kind of resistance to use if any, and what tempo to follow to most effectively complete the exercise. The app has an option to record a video of the user doing the exercise, which could then be used for review. After each exercise, the user selects on a scale of 0-10 the pain experienced while completing the exercise. If the user selects an option greater than 0, they are notified to contact their physical therapist. At the end of the seven exercises, the user can claim a reward in the form of a trophy to add to their collection. The rewards and positive statements on the congratulatory page are part of the action-based behavior model, where the user can be motivated and persuaded to continue with the exercises. Notifications are also sent each day to remind the user to stay engaged with the program. These reminders and rewards should increase patient engagement and monitoring, and will thus hopefully prevent the worst outcomes associated with hip fracture.
- 5. Benefits: The benefits of the myHipRehab app are that it implements features that have been utilized in other recovery apps individually on a single, easy-to-use platform. It combines the idea of monitoring exercise accuracy (similar to pose tracking in Exerceo [6]), using a simple interface for patients to view their exercise regimen (similar to PhysYou [3] and Physical Therapy App [4]), and having a way for doctors and patients to monitor the progress from the videos that are sent from the video recordings (similar to Patellr [5]). Putting these features together makes the app competitive in the hip recovery market and will provide its users with a greater sense of empowerment.

The following sections will provide a more in-depth explanation of the myHipRehab mobile app. They will expand on the motivations for creating the project, explore a few example situations related to it, and will finally explain the app development process and its architecture. The reader should end the paper with a complete view of the myHipRehab app and its potential impacts.

II. MOTIVATIONS

As alluded to above, the main motivations of the myHipRehab app are to provide constant and consistent support to patients after hip surgery in order to avoid the common failures associated with the recovery process.

One of the first areas targeted by the app is patient emotional well-being. It is widely supported that mental and physical health have a cyclical relationship. One study from the Archives of Physical Therapy [7] stated that “aerobic and strength exercises...reduce psychological distress.” It thus follows that an app like myHipRehab that encourages safe exercise could lower mental distress as well.

Compounding the possible mental distress after surgery is the fact that chronic pain is also linked with poor mental health [8]. One potential reason for depression due to chronic pain is a perceived loss of purpose. This feeling would be had by many hip surgery patients, as a decrease in mobility caused by their joint pain could make it difficult for them to perform their regular habits of daily life. Whether a patient had a planned hip procedure or an unforeseen hip fracture, they would likely become limited in terms of their social life and mobility for a significant period of time afterwards. A Translational Psychiatry study from 2020 [9] found that individuals with a sedentary lifestyle had a “positive association” with depression risk with $P < 0.01$. Examples of “sedentary behaviors” were those that are “mentally passive.” This includes watching TV and talking or listening without a clear objective [8]. All of these activities are common for someone in recovery, whether in the hospital or at home.

On top of the distress caused by mobility issues, recent depression can make it harder to take on new tasks such as a physical therapy routine. A study in the Cognitive, Affective, Behavioral Neuroscience journal found that in some cases, depression and low motivation can combine to decrease cognitive control [10]. In other words, if a patient’s mental health is struggling, it can be harder for them to commit to new projects. Therefore, when it is time for them to transition to active physical therapy, they may experience burnout or lack of motivation.

These examples emphasize the importance of supporting a patient’s emotional well-being through a physical therapy regimen. It is clear that a rehabilitation app like myHipRehab needs to engage users mentally as well as physically by providing them with consistent and safe post-surgery exercises. These exercises can help the patient remain active and will lower their pain levels throughout their physical recovery, benefiting their mental and physical health in the long run. Our app uses a simple to understand exercise regimen to help meet this goal.

A second, related motivation for the app is to promote ease of use, which would help to maintain patient engagement and therefore also benefit mental and physical health. Good app design is critical to reaching this goal and to maintain the user’s attention, so it was a focus in our development process. According to the Cognitive Research Journal [7], the perceived efficiency of an app was linked with user interest. Additionally, users respond positively to color variations, suggesting that it contributes to “smooth interaction” with the app. Clearly, an app’s interface must be eye-catching and deliberate to engage with the user and to cater to their needs. myHipRehab therefore uses a clean layout with bright colored accents to

help reach its goals of maintaining user interest.

The final motivation for our physical therapy companion app is to ensure it has medical integrity. The app must take measures to promote healing and prevent injury. Since the device is acting as a stand-in to a real provider, in accordance with the Hippocratic Oath, it must “first do no harm.” We adhere to this motivation by using an exercise plan created by physical therapy researchers. The ability for app users to interact with their medical professionals also has potential to assist with this task.

III. CASE OF STUDY

While our app did not have a concrete or published dataset to work with, it did utilize an exercise prescription plan, which was provided to us by Dr. Benjamin Gordon in the Department of Health and Human Performance at the University of Florida. The plan was developed from two sources: a 2020 literature review by Lee et al. [11] and a 2014 randomized clinical trial by Latham et al. [12].

The data in this plan was associated with seven different exercises, each of which was chosen to help optimize recovery from hip fracture and a subsequent hip pinning surgery. The features elaborated on for each exercise included the number of sets and repetitions the patient should perform at a given time, the tempo of muscle lengthening and contraction that should be used to most effectively complete the exercise, any resistance equipment needed, and the optimal rest time to take in between sets. A GIF demonstrating each exercise was also provided, as was information about how the program should change with each week of recovery. We used the data from this plan to structure and inform our app design.

IV. PROPOSED MOBILE APP SOLUTION

The approach for the myHipRehab app will be detailed below. Overall, it was designed with user convenience and efficiency in mind, as well as to help patient empowerment. The flow of the app is straightforward, starting with a home page, moving onto the exercises, and then ending with a “Congratulations” page. The user has the option to go back to reread directions or start over at their own pace, but the striking graphics will encourage them to select the logical next step when it is time.

A. App Structure

myHipRehab’s structure is meant to be simple, linear, and intuitive. It begins with a login page, which is connected to the Firebase platform for proper authentication and to store user data. Upon clicking “Login” or “Sign Up” in Figure 1, the user is brought to the “Welcome” page, which gives helpful context about the exercise program. The “Get Started” button takes the user to the first exercise, and each “Next Exercise” button afterwards will take the user to the subsequent exercise page. Each button is clearly labeled and brightly colored so that the user is compelled to click it.

The core of the app is the seven exercise pages, which all follow the same general layout. Each exercise page features a

demo of the exercise as well as the instructions to perform it correctly. In addition to the “Next Exercise” button, a “Record Video” button can be pressed to open the camera on the user’s Android device. The app finishes with a congratulatory page once the user goes through the entire program. The user is rewarded with a virtual trophy at the end to instill motivation. This easily shows the user the relationship between completing their exercises correctly and concluding the routine.

Additionally, myHipRehab is able to send notifications to the user’s phone through Firebase’s Cloud Messaging service to remind the user to log back into the app, an example of the remind feature in the action-based behavior model. This notification system will encourage the user to log back into the app and continue their recovery.

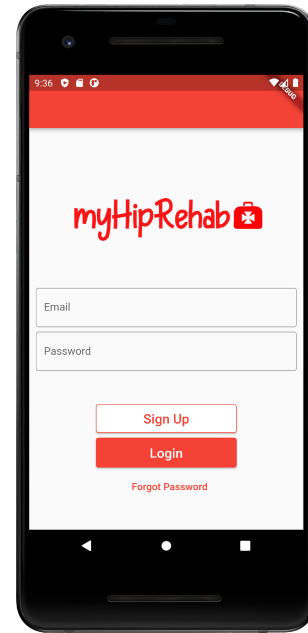


Fig. 1. myHipRehab login screen with options to login, sign up, or retrieve password.

B. App Development

myHipRehab was developed using the Flutter SDK and Dart language in Android Studio IDE, which gives it the ability to use the CARP plug-in. While we did not have issues with the Flutter platform, the CARP framework proved to be unnecessary for our app needs, as we focus primarily on video rather than using built-in sensors such as the accelerometer or gyroscope. The resources used for the project include the following:

- StackOverflow
- TutorialKart
- Flutter API Reference Documentation
- Pub.Dev
- Google Fonts
- Dafont.com
- Gimp 2.10.28

- flutter_camera plugin

The user interface design was developed with clarity, the Gestalt principles, and color theory kept in mind. The myHipRehab logo was created in Gimp using “Frankie Healthy” and “Hospital Icons” fonts found on dafont.com. The medical icon to the right of the text was chosen because it signifies medical care which is analogous to rehabilitation. The overall theme colors of white and red were selected to mirror the typical colors seen in the medical field. On screens with more than one button, we chose to differentiate them by inverting the red background and white font for contrast.

Additionally, myHipRehab’s components follow a grid layout and use negative space wisely to support symmetry and provide an overall pleasing aesthetic for the user. Furthermore, the Gestalt principles of similarity and symmetry are seen throughout the product design as the same layouts, colors, and fonts are repeatedly used to create a pleasing visual experience. Color theory principles were also used and can be seen in the use of the contrasting red and white colors throughout the app, as well as on the pain scale, which uses the green smiley icon for a pain level of 0 and a red smiley icon for a pain level of 10, where were created in Gimp. Finally, myHipRehab has fonts that are clear and easy to read on a screen. All of the aforementioned components were decided upon to improve the overall user experience. Upon opening the

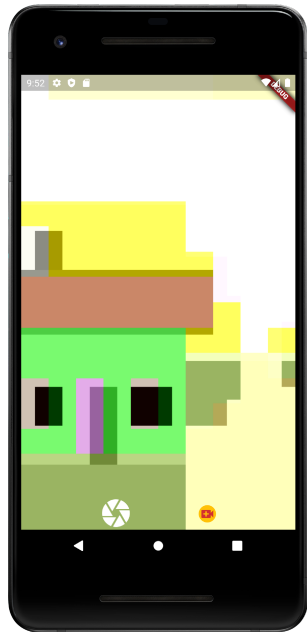


Fig. 2. After the user clicks “Record Video”, the front camera of the user’s Android is accessed to record a video of the user completing the exercise.

app, the user will see a login screen with buttons to sign up or login with a user’s credentials, as well as a button for in case the user forgets their password. The username and password credentials are stored in the Firebase platform. Upon logging in, the user is greeted with a “Welcome” screen that lists some reminders regarding the number of times the exercises should

be performed, repeating exercises bilaterally, and choosing an appropriate resistance. There is also a message to remind the user about the progression of these exercises. Once the user clicks “Get Started”, the user is brought to the first exercise: hip extensions. Each exercise page, Figure 3, lists the number of sets, repetitions, rest period, resistance, and tempo and has a large GIF of a person demonstrating the exercise. There is

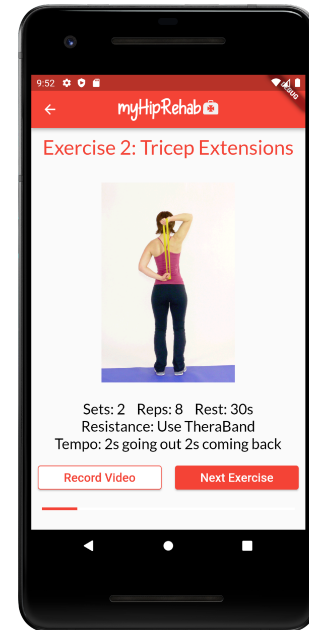


Fig. 3. myHipRehab’s second exercise screen with large GIF, number of sets, number of reps, resistance, and tempo. The progress bar is displayed at the bottom.

one button to record a video of the user doing the exercise, Figure 2, and another to advance to the next exercise. When the user clicks “Next Exercise”, a dialog appears to request the user’s pain feedback on a basic scale of 0-10 with 10 being extreme pain, shown in Figure 4. If the user taps any number other than 0, an additional dialog appears to ask the user to contact their physical therapist. At the bottom of the subsequent exercises, there is a linear progress bar so that the user is aware of their progression status within the program. The remaining exercises are tricep extensions, chair squats, double arm lift, step up and down, diagonal reach, and calf raises. After completing seven exercises, the user will see a “Congratulations” screen where they can click on the button that says “Claim Reward!” to add a virtual trophy to their collection to provide motivation and empowerment for the user. Upon clicking the button, confetti appears in the background of a dialog with an image of a trophy and the total number of trophies the user has, Figure 5. On the “Congratulations” page, the user is reminded to repeat the exercises three times a week and to keep up the good work.

The following is a hyperlink to the shared repository used for this project: [Github Link](#)

The following is a YouTube hyperlink that demonstrates the project in action: [YouTube Demo](#)

V. DISCUSSION

For those that have undergone intensive hip surgery, the post-operative regimen is essential for complete recovery. myHipRehab acts as a guide for the user during this recovery by walking through a typical physical therapy set of exercises and presenting the material in a fun, interactive way. Despite the several available solutions in the rehabilitation market, myHipRehab stands apart by focusing on the action-based behavior model to persuade more consistent user engagement.

myHipRehab consists of specific features that are centered around the user in order to enhance their experience. For example, myHipRehab includes a “Record Video” feature so that the user can see themselves doing the exercise as well as the option to send the video to the provider so the user can be sure they are doing the exercise correctly. Additionally, myHipRehab allows the user to claim their trophy once completing all seven exercises. This virtual trophy acts as a confidence booster and lets the user know that their efforts are valued. The trophies are part of the action-based behavior model given that they persuade and encourage the user to return to the app to grow their trophy collection. The rewards feature and physically doing the exercises aim to improve the user’s mental and physical health. The rewards act as an overall morale booster and the exercises persuade the user to participate in body movement which has been proven to benefit mental health [7].

For future work, the incorporation of pose sensing and estimation would be a great addition to the app that would provide real-time feedback on if the user is doing the exercise correctly. In addition, a messaging feature between user and physical therapist would be ideal for if the patient experiences pain while completing an exercise and what steps to take.

VI. RELATED WORK

Related apps similar to myHipRehab include Patellr, in which this app tracks patients as they progress through knee rehabilitation [5]. Another similar app is Exerceo, which uses visual tracking of poses to accompany rehabilitation [6]. Another app is the Physical Therapy App which allows doctors to create a customized rehabilitation plan for their patients, and to allow them to communicate with them [4]. A final app is PhysYou, which allows doctors to prescribe exercises for rehabilitation and to track progress [3].

A similar study to myHipRehab is “Smartphone app for total hip replacement and total knee replacement surgery patients,” which critiques the current array of apps on the market to assist with hip and knee surgery [13]. Another study is “Feasibility and Patient Experience of Home-Based Rehabilitation Program Driven by a Tablet App and Mobility Monitoring for Patients After a Total Hip Anthroplasty,” which examines the benefits of a table-based app that delivers exercise routines [14]. A final study is “RECOVER-E - a mobile app for patients undergoing total knee surgery or hip replacement: study protocol,” which covers pre-surgery, surgery, and rehab for patients with knee or hip replacements [15].



Fig. 4. After the user clicks “Next Exercise”, a pain feedback dialog pops up allowing the user to select on a scale of 0-10 any pain encountered during the exercise.

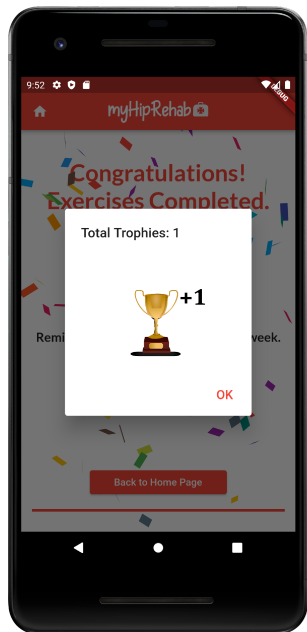


Fig. 5. When the user clicks “Claim Reward!”, the user receives a trophy and confetti is displayed.

VII. CONCLUSIONS AND FUTURE WORK

myHipRehab, as discussed above, is a competitive rehabilitation app that can be used to help with recovery after hip pinning surgery. Through its engaging UI, clear instructions, and use of the action behavior model, the app increases user empowerment to help lessen the mental and physical tolls associated with a hip fractures.

While the app works well as it is, we would like to expand upon it in the future. Our development plan always included adding in a pose estimation algorithm to our video recordings, which would help to ensure the user is doing the exercise correctly. If the user is doing the exercise incorrectly, the app would tell the user what to adjust. Unfortunately, we ran out of time to correctly implement this feature for this project, and so it had to be temporarily cut.

As we move forward with the app, we plan to add pose estimation through making use of Flutter's TensorFlow Lite package. This package would give us the ability to analyze each frame from our videos and to compare it to the pose data from our demonstration GIFs, which could then be used to evaluate the user's form. On a smaller scale, we also plan to add in a direct messaging feature utilizing Firebase's Cloud Messaging, which would enable patients to contact their physical therapist directly through the app.

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