ENGAGING LOW BACK PAIN PATIENTS IN PHYSICAL THERAPY: DEVELOPING A MOBILE APPLICATION TO IMPROVE ADHERENCE

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ABSTRACT

Low-back pain (LBP) is a global health issue with significant disability and economic burden. We designed a mobile platform that combines usability, gamification, and reminders to assist LBP patients in their home environment. The platform aims to reduce LBP recurrence, treatment burden, and costs while promoting exercise adherence and engagement. Using text-to-speech and speech recognition techniques to enhance motivation and facilitate daily exercise practice. The application was reviewed by a user experience (UX) professional and a therapist to evaluate its usability and real-world applicability.

Keywords: Mobile health. Mobile platform. Physical exercise. Low back pain. Usability.

1 INTRODUCTION

Low-back pain (LBP) is the main and the leading cause of disability globally (HAYDEN et al., 2021). It's the main cause of years lived with disability (YLDs) for all conditions studied by the Global Burden of Disease (GDB) in 2017 (WU et al., 2020). The number of people with LBP was estimated to be 577 million in 2017. Being more prevalent in Southern Latin America (13.47%). It occurs in low-income, medium-income, and high-income countries affecting all age groups, being more predominant in females (HARTVIGSEN et al., 2018). LBP is notoriously present among people with low socioeconomic status.

The economic impacts of LBP affect multiple sectors due to the increase in cost in both health care and social support systems (HARTVIGSEN et al., 2018). Affecting negatively the social system in low and medium-income countries. In high-income countries, the concern is that the prevalent approaches used in health care contribute more to the burden and the cost rather than reducing it (HARTVIGSEN et al., 2018). Which turns LBP into a public worldwide health concern.

The practice of physical therapy exercises for low-back pain treatment has been shown to be effective. Reducing low-back pain and disability has a positive effect both for patients who can return to their jobs and for companies, resulting in fewer sick leave (KUUKKANEN et al., 2007). In addition, there has been strong evidence of a reduction in the recurrence of the LBP with the practice of the exercises in a period of 12 months or less.

The exercises can be practiced by the patient in their home, improving the outcome of the patient. Home-based exercises are effective for LBP treatment, and the most important factor for the effectiveness is the adherence of the patient (ANAR, 2016). The

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adherence varies from 35–84%, affecting the effectiveness and cost of the treatment and possibly the statistical result of clinical studies made by researchers. There are many factors that can impact adherence, including motivation, age, pain level, enough time to practice the exercises, and beliefs in the good outcomes of the exercises. The increase in pain while practicing the exercises is a strong factor affecting adherence (ANAR, 2016).

Although there are free-of-charge mobile applications designed to assist with the practice of physical exercises, according to the review by (COE-O'BRIEN et al., 2020), the majority of the applications available in Google Play Store and Apple Apps Store received a mean score of 2.54 out of 5 for MARS, indicating that the overall quality of the apps is not great. Also, the apps haven't been found mentioned in scientific literature, which indicates a lack of scientific evidence.

Hence, we considered the multidisciplinary approach proposed by (PADILHA, 2022) to define the goal of the present study as to design a mobile platform to treat low-back pain, focusing on usability, engagement through gamification, and reminders to assist LBP patients automatically at home. As specific goals, we propose to develop a prototype of the application; to evaluate the application regarding good practices on usability and user experience. As an expected result of using our application, this can reduce the recurrence of LBP, the burden, and the costs of the treatment. The flexibility of the treatment, the automated assessment, and the tracking of the patient's pain before and after the exercises turn it into a valuable platform for physiotherapists and patients. Healthy persons can also practice the exercises as prevention for LBP.

Speech recognition and text-to-speech will be applied to motivate the patients, engaging them to practice the exercises in a daily manner. The use of these functionalities can transform a physiotherapy experience into a more attractive activity, facilitating the recovery of the patient.

2 RELATED WORKS

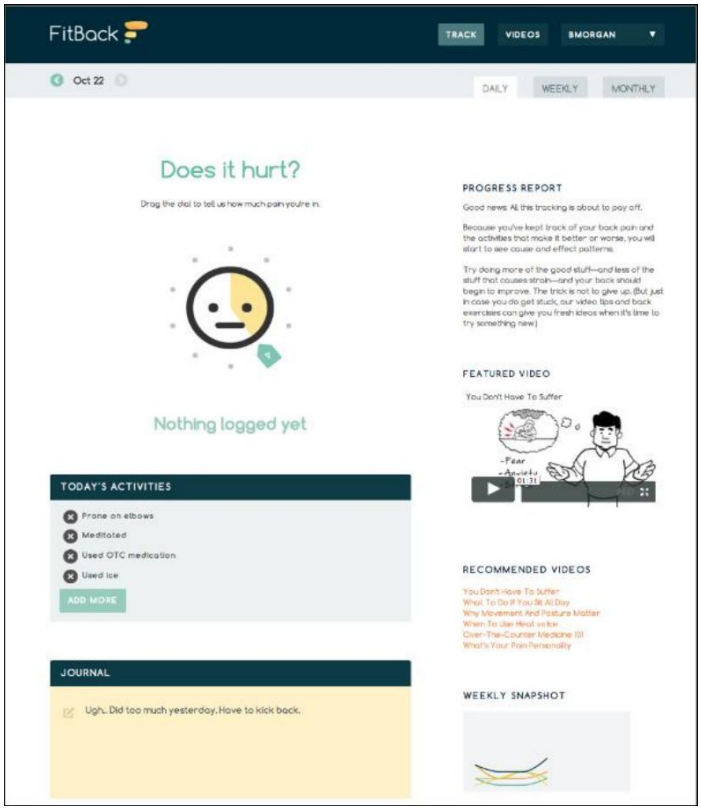
In 2015, IRVINE et al. proposed FitBack, an online website with educational content about non-specific low-back pain and behavioral strategies to prevent and manage pain episodes. The proposed application, shown in Figure 1, can be accessed on a computer, or on mobile devices such as smartphones, tablets, due to its responsive design. A total of 597 adults participated in the clinical trial. The results show that the users of the FitBack platform improved their behavioral, physical, and worksite outcome compared to the control group. They had a better performance on current pain, behavioral, and worksite outcomes that were measured during 4 months. However, professional caregivers didn't participate in the intervention, which could have improved the intervention with additional support for the participants.

(HUBER et al., 2017) analyzed data from 180 users from the public Kaia health mobile application. Kaia offers a multidisciplinary approach that includes educational content such as videos and mindfulness exercises to treat low-back pain. Although there was a significant dropout of users over time (17.8%, 32/180), the results demonstrate a significant reduction in pain level from a 4.6 mean to 2.60 after 12 weeks. This illustrates how a multidisciplinary approach can be effective to reduce the patient's pain level.

(SANDAL et al., 2020) created selfBACK, a mobile application with educational

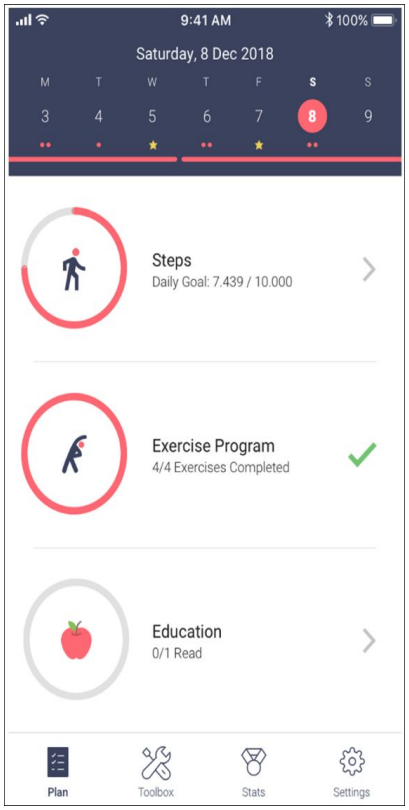
content as well as exercises progress tracking, with a dedicated menu to see the statistics. The Figure 2 shows the user interface of the exercise tracking and education features. Unfortunately, the application doesn't provide motivational messages to inspire participants to continue their practices.

Figure 1 – FitBack website



Source: Irvine et al. (2015, p. 3)

Figure 2 – SelfBACK mobile application



Source: Sandal et al. (2020, p. 4)

3 MOBILE HEALTH APPLICATIONS REVIEW

(COE-O'BRIEN et al., 2020) evaluated mobile health applications published on Google Play Store and Apple Apps Store. A total of 74 applications were analyzed according to the International Classification of Functioning, Disability, and Health (ICF) core set classifications for LBP and the Mobile Application Rating Scale (MARS). The apps received a mean score of 2.54 out of 5 for MARS, indicating that the overall quality of the apps was not great. Unfortunately, the apps haven't been found mentioned in scientific literature, which indicates a lack of scientific evidence.

The information category received the lowest score, with a mean of 1.72 out of 5, indicating an absence of enough useful information about low back pain. Engagement also received low scores, with a mean of 1.77 out of 5, indicating that the apps were not engaging enough to promote consistent usage and adherence.

Only 4 of the 74 apps included outcome measures to assess patients' pain and functional status. They were implemented primarily as questionnaires with a focus on ratings of pain, psychological factors, and activities of daily living (ADLs). Only one

application used an outcome measure that is studied in the scientific literature, the Back Pain Functional Scale (COE-O'BRIEN et al., 2020).

4 METHODOLOGY

To create the application, we collaborated with the authors of the multidisciplinary protocol for low-back pain treatment (PADILHA, 2022). We gathered the requirements through interviews with the authors, where we sought to understand the needs and goals of the target users, focusing on the most valuable features for usability and engagement. The requirements were documented as user stories, which captured the essential functionalities and interactions desired by the users. The user stories (HELM; WILDT, 2014) were prioritized based on their perceived value and impact on usability and gamification.

The application was developed following the agile methodologies, mainly Scrum (SUTHERLAND, 2014). We organized the development into interactive sprints, with each sprint having a duration of two weeks. The team was composed of developers, colleagues from the same course at La Salle University, and domain experts who collaborated to implement the user stories.

To evaluate the usability and real-world applicability of the application, we conducted a review process with a user experience (UX) professional, and a therapist. The usability sessions were recorded, and the feedback was collected and analyzed. User experience professionals and therapists evaluated the application, providing insights on its usability and alignment with clinical practices.

Ethical considerations, such as obtaining informed consent from participants and ensuring data privacy and security, were carefully addressed throughout the development and evaluation process.

5 DESIGNING THE MOBILE APPLICATION

We designed the application on Figma, using design tokens. The application was developed using React Native stack, with Typescript, Tailwind CSS[2], pnpm[3]. React Native allows the development of a single code base for multiple platforms, in this scenario, for both Android and iOS, which is a significant advantage as it saves development time and resources. We can focus on usability which maintains consistent across multiple platforms. The hot-reloading feature promotes a faster development cycle, allowing the changes made to the code to be seen more rapidly, reducing the overall development time.

We used Tailwind CSS which promotes a different approach for styling applications, it's a CSS framework with utility classes for styling the components directly in HTML. It scans the HTML files, React components for CSS class names, generating CSS styles that are bundled into a static CSS file. It's flexible, reliable, and doesn't include any processing at runtime.

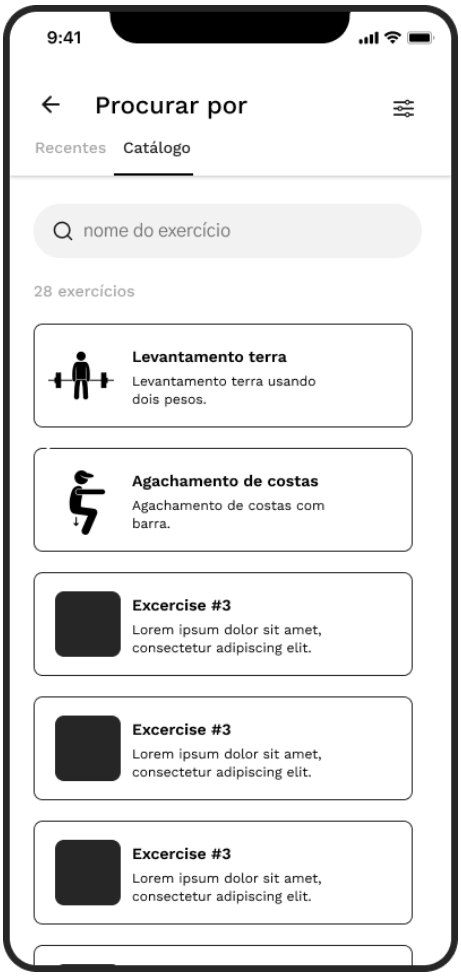
[2] https://tailwindcss.com
[3] https://pnpm.io

5.1 Exercise catalog

The exercise catalog, shown in Figure 3, is a library of exercises categorized by body parts, muscle groups, exercise type, and difficulty. It allows therapists to find the most relevant exercises for their treatment. The catalog is diverse and contains exercises for different physical conditions and body parts, allowing therapists to prescribe the most relevant exercises for their patients. For each exercise, there is a detailed description that includes instructions on how to perform the exercise correctly, possible side effects, and precautions. The catalog includes demonstration videos to illustrate to patients how to perform the exercises. The videos are an essential component of the catalog, as they provide a visual reference that can help patients understand how to perform the exercises safely and effectively.

To make the catalog more efficient, therapists can search the exercises by name, condition, or difficulty, as shown in Figure 4. The exercises are categorized by body parts, muscle groups, or exercise types, such as stretching or muscle strengthening. The level of difficulty of each exercise allows therapists to choose exercises that are more appropriate for their physical ability. This also allows patients to progress in their treatment plan as they improve their physical ability.

Figure 3 – Exercise catalog



Source: The authors

Figure 4 – Exercise catalog filters

Source: The authors

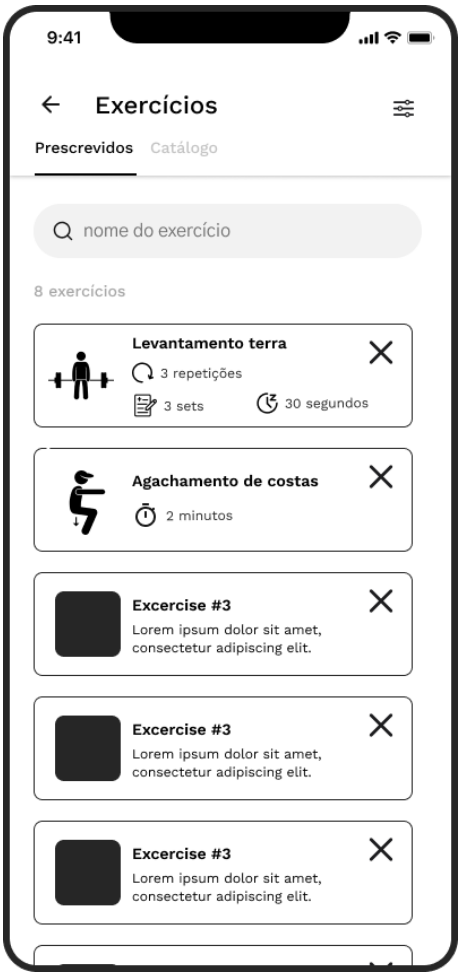
5.2 Exercise plan

Therapists can create a personalized treatment plan according to the physical ability of the patient. They can select exercises from the catalog, according to the conditions of the patient. For instance, if the patient has lower back pain, the therapist can select exercises that target the lower back muscles, such as abdominals and lumbar extensors. If the patient has tight hamstrings, the therapist can, as well, select stretching exercises that target the hamstrings.

As Figure 5 illustrates, with the exercises selected, the therapist can personalize the exercise plan for the patient. He can specify the number of repetitions and duration of each exercise. If the patient has a higher physical ability, the therapist can prescribe more repetitions or longer durations, with the possibility to include harder exercises. Alternatively, if the patient has a low physical ability, the therapist can prescribe fewer repetitions of shorter durations with longer periods of rest.

A personalized schedule is created with the patient, determining the time between each session, the days of the week, and the best time to practice the exercises. For example, the therapist can recommend to a patient to practice the exercises three times a week, with a day of rest between each session.

Figure 5 – Exercise plan for a patient



Source: The authors

Figure 6 – Customizing exercise for patient

Source: The authors

5.3 Exercise reminders

A great challenge the patients face when practicing the exercises outside the clinic is remembering to do them regularly. To help patients, we implemented a personalized reminder system that notify patients when it is time to practice their exercises. Patients are able to configure reminders based on their preferred time of day, frequency, and duration of their treatment plan. Allowing patients to stay on track with their exercise plan and avoid missing sessions.

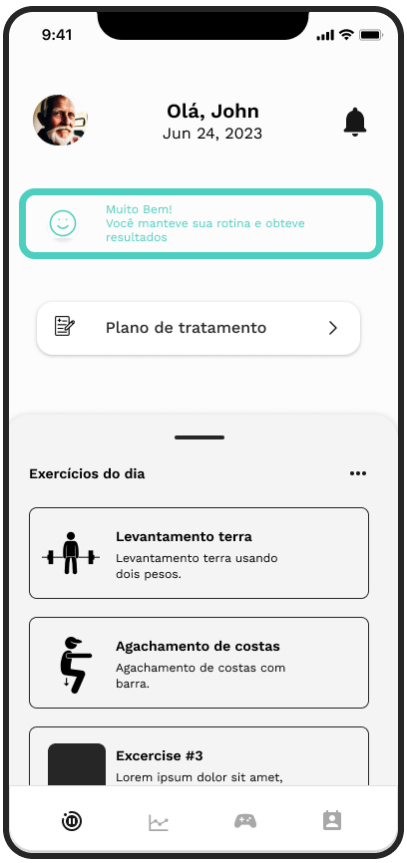
The reminders can be customized based on the patient's preferences and needs. Some patients may find it more helpful to receive detailed instructions, while others would be glad to receive motivational messages to support them. Patients can configure the reminders they would like to receive, making them more comfortable, and increasing their adherence to the treatment plan.

The reminder system also sends push notifications when the patient missed a session or is failing to do their exercise plan. The notifications remember the patient to continue the sessions later, helping them to remain consistent with the treatment plan.

5.4 Home screen

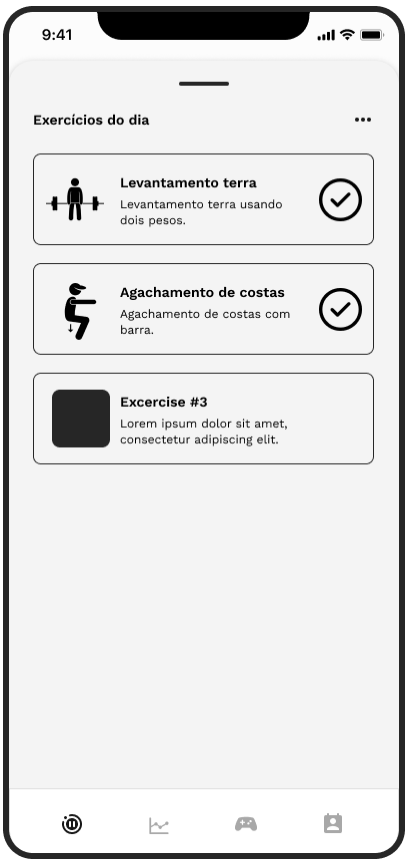
The home screen, illustrated in Figure 7, serves as the central hub where users can access their treatment plan and view the exercises scheduled for the day.

Figure 7 – Application Home screen



Source: The authors

Figure 8 – Home exercises completed



Source: The authors

Upon completing an exercise, users can track their progress on the home screen

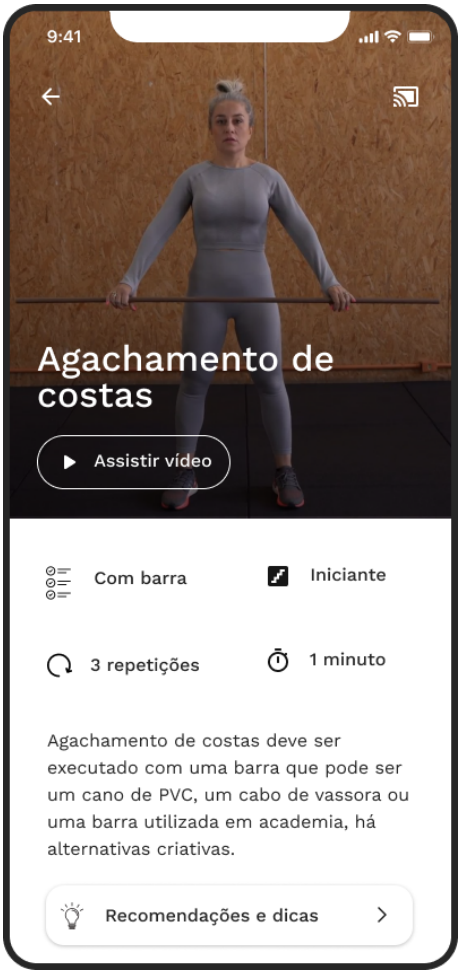
by observing a checkmark next to the exercise, as in Figure 8. This visual indicator helps users keep track of their completed exercises and stay motivated throughout their treatment journey. Additionally, the home screen displays the user's profile and notifications, including updates to the exercise plan or additional feedback from their medical personnel.

5.5 Exercise practice

One of the key implemented functionalities is the ability to initiate the exercise routine using voice commands. Users can conveniently start their exercises by using voice prompts, for instance, "start exercise", eliminating the need for physical interaction with the app. This feature enhances accessibility and convenience, allowing patients to focus solely on performing their exercises.

The exercise demonstration and information functionality provide users with concise instructions and guidance. As illustrated in Figure 9, users can access detailed information about each exercise, including a button to watch a demonstration video for additional guidance. To ensure a comprehensive understanding of the exercise, recommendations and hints are also available, accessible through the recommendations button at the bottom of the screen.

Figure 9 – Exercise information screen



Source: The authors

Figure 10 – Exercise practice screen

Source: The authors

The exercise information screen from Figure 9 presents users with the number of repetitions to be performed for each exercise. The duration is present if the exercise was prescribed to be practiced for a period. This information helps users adhere to their prescribed exercise regimen and ensures they practice the exercises correctly and for the appropriate duration. To test the exercise demonstration functionality, well-known exercise videos from YouTube were utilized.

The exercise practice screen from Figure 10 provides users with a seamless and guided experience while performing their exercises. When the user starts an exercise, they are presented with real-time progress feedback, which includes the current repetition count or the duration they should continue practicing the exercise.

As the user completes each repetition, the application delivers audio and visual feedback, signaling a brief rest period before the next repetition. During the rest interval, the user is continuously informed about the remaining time for the rest period through periodic audio and visual notifications. This helps users stay aware of the rest duration and prepares them for the next round of exercise.

Once the rest period ends, the application sends a voice message, prompting the user to "practice again", signaling the start of the next repetition. This guided approach ensures that users maintain proper pacing and stay on track during their exercise routine.

The exercise practice screen seamlessly transitions between exercises. As shown in Figure 11, when one exercise is completed, the application announces the next scheduled exercise to the user. The user can conveniently initiate the next exercise using a voice command, streamlining the exercise practice process and eliminating the need for manual interactions.

Upon completing all scheduled exercises for the day, the user is presented with a comprehensive feedback screen shown in Figure 12. This feedback screen provides valuable statistics about the exercise practice session, including the total duration of the exercises completed and the number of exercises performed. Additionally, the user has the option to report any instances of pain experienced during the exercises and indicate the intensity of their exercise practice.

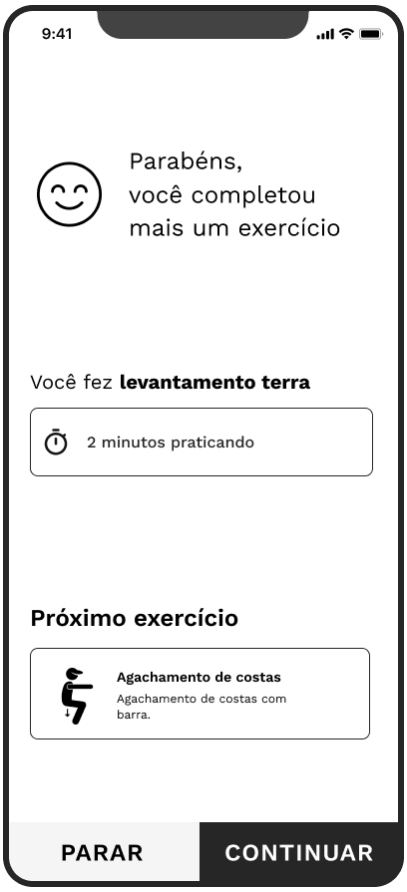
6 EVALUATION

The developed application was thoroughly reviewed using input from a user experience (UX) professional and a therapist, the author of (PADILHA, 2022). The feedback received was largely positive, highlighting the usability and enhanced features compared to similar mobile applications designed for a similar purpose.

The UX professional acknowledged the application's great user experience for patients, particularly emphasizing the inclusion of advanced features such as text-to-speech and speech recognition. These features significantly contribute to the overall usability of the application, allowing patients to control the app and their exercise practices more efficiently.

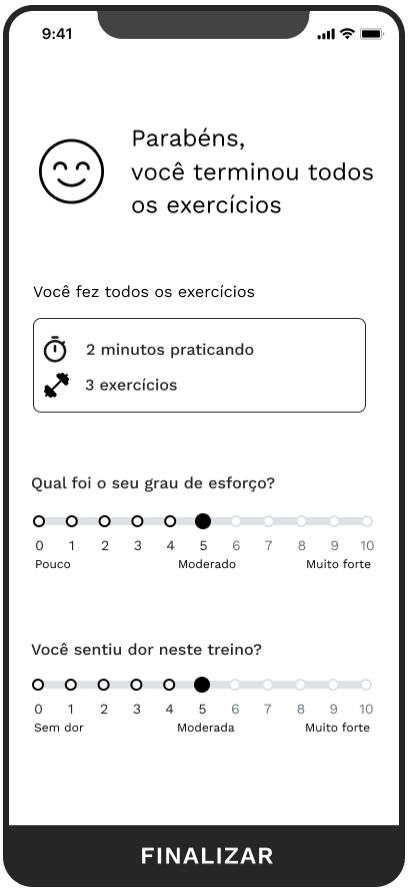
During the review process, the therapist expressed satisfaction with the usability experience. She provided valuable suggestions for further improving the patient's exercise practice experience. One such suggestion was to incorporate additional voice commands to offer a more immersive and interactive guidance system for patients

Figure 11 – Exercise finished screen



Source: The authors

Figure 12 – All exercises finished Feedback



Source: The authors

during their exercise routines, as an alternative to indicating time-lapse or counting repetitions.

These suggestions and feedback from the UX professional and the therapist will be carefully considered for future iterations and updates of the application.

7 CONCLUSION

In conclusion, we have successfully designed a mobile application with a strong emphasis on usability and user experience. Through the review process involving a therapist and a UX professional, we have received positive feedback on the application's usability and advanced features. The inclusion of text-to-speech and speech recognition has significantly enhanced the user experience, allowing patients to have greater control and efficiency in their exercise practices.

As future work, the integration of a gamification approach (JANSSEN et al., 2017) holds promise for further enhancing the application's impact. By implementing a reward system, introducing exercise variations, allowing users to adjust exercise intensity, and incorporating dynamic difficulty adjustment (DDA) technology, the application can foster motivation and engagement among patients. Gamification has the potential to transform the exercise practice experience, making it more enjoyable, interactive, and conducive to achieving desired health outcomes.

Overall, the designed application has achieved the intended objectives. Its emphasis on usability, user experience, and integration of cutting-edge technologies demonstrates the potential to improve patient adherence, engagement, and overall treatment outcomes.

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