Web-based Platform providing ongoing Rehabilitation Support for Stroke Victims

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Abstract. The aim of this work is the development of a digital platform to support the physical rehabilitation of stroke patients who were cleared to transition to home-based and outpatient rehabilitation.
This digital solution facilitates real-time communication with physiotherapists, disseminates stroke educational content to boost patient health literacy, and complements rehabilitation protocols through guided exercise videos and session monitoring (including repetition counts, scheduling, and time tracking).
The development consisted of a Progressive Web Application (PWA), a hybrid solution functioning as both a web browser application and a native app. Its layered architecture isolates UI components from backend operations. By combining modern and robust technologies, we created an accessible and secure application capable of real-time communication between users and physiotherapists. This streamlines rehabilitation activity tracking and enhances patient well-being. In-situ evaluation is scheduled for the subsequent project phase, to be carried out through partnerships with healthcare providers.

Keywords: e-health · web application · stroke · remote monitoring.

1 Introduction

Stroke is one of the leading causes of death and disability worldwide [13]. After a stroke, many patients require various treatments, including physiotherapy, which helps and accelerates the recovery process, enabling gradual return to daily activities with greater autonomy and minimal sequelae. Given this context and the need to accelerate recovery, total or partial, there emerged a clear a need to implement a digital solution that would work as an extension of therapeutic sessions conducted in a clinical environment.

The solution to be developed is based on a hybrid web platform, that is, one that works on any browser and mobile devices. The satisfaction of these basic requirements is guaranteed by the use of modern and robust technologies, particularly PWA. This architecture makes the entire digital platform compatible with any device, eliminating the need to develop specific code for different operating systems.

Our work aims to address specific challenges in the field of physiotherapy, namely improving communication between physiotherapists and patients, disseminating health information related to stroke, and, most importantly, ensuring continuity of physiotherapeutic procedures in the absence of the professional and in a home environment. It is believed that the greater the exposure of patients to physiotherapeutic activities, the faster the recovery process can be. The work done by the patient is monitored through consultation of information collected by the application in the context of specific exercise execution, providing a set of data for the physiotherapist to analyze and adjust, if necessary, the treatment being performed by the patient. It should be noted that treatment is individualized so that each patient has a specific plan to address their unique challenges, as stroke manifests in various ways.

Following this introduction, the remainder of this paper is structured as follows. Section 2 delves into the foundational concepts and existing literature relevant to the development of the platform. Section 3 describes the system proposal, covering various topics including system specification, system design, technical details, system architecture, technologies used, interface design and implementation. Section 4 presents the results and discussion of the results. Finally, Section 5 concludes the paper by summarizing the main contributions, discussing the implications of our work, and future work.

2 Theoretical Foundation and Related Work

Post-stroke patient rehabilitation represents one of the most pressing challenges in public health and biomedical engineering, given the high prevalence of the condition and its long-term functional consequences. Beyond in-person rehabilitation, it is crucial to ensure the continuity of treatment outside clinical settings, ideally in calm environments, through the use of digital technologies that support therapeutic plans in the absence of healthcare professionals. The advancement of mobile health applications (mHealth) and telerehabilitation platforms has fostered the development of solutions aimed at supporting remote physiotherapeutic monitoring. Studies such as that by Rintala et al. [1] report significant improvements in physical function and motor activity among stroke survivors who used mobile applications incorporating physical training components, although the impact on quality of life remains inconsistent, highlighting the need for more interactive and personalized tools. Works such as that by Gonçalves et al. [2], with the RehabApp application, demonstrate the effectiveness of gamification, educational videos, and subjective metrics in enhancing patient adherence, and these strategies can be adapted to neurological pathologies. Solutions like ExerciseCheck [3], which integrates motion sensors for quantitative analysis and real-time feedback, and the system proposed by Ar and Akgul [4], underscore the potential of remote monitoring, despite reliance on specific hardware. Similarly, Ramos [5] and Silva [6] introduced interactive telerehabilitation platforms featuring asynchronous communication and exercise-monitoring sensors, further reinforcing the role of digital technologies in clinical follow-up.

3 System proposal

Within this context, the proposed platform, FisioStroke, was designed as a PWA with a Spring Boot (Java) backend and an Angular (TypeScript) frontend, ensuring a responsive interface, scalable integration, and ease of maintenance. The solution supports playback of clinically recorded videos, automatic data collection, gamification elements, asynchronous chat, creation of exercise plans, and a robust authentication system, with data stored in a MySQL database. The architecture follows a client–server model and employs the MVC pattern in the backend, ensuring a clear separation of responsibilities between the interface, business logic, and data persistence. Communication between layers is handled via REST APIs and WebSockets for real-time interaction. User roles (administrator, physiotherapist, and patient) govern access and permissions: administrators manage accounts and content, physiotherapists create and edit plans, generate access codes, and monitor statistics, while patients execute prescribed exercises, record videos, track progress, and receive feedback. Video metadata is stored in the system, while files remain on the user's device, thereby preserving privacy.

The communication implemented in FisioStroke is asynchronous and not real-time. Messages exchanged between patients and physiotherapists are delivered through a WebSocket-based messaging system, which ensures low latency and immediate delivery under normal network conditions. However, the interaction model does not require both parties to be online simultaneously, as messages are stored and made available for later consultation. Thus, although the underlying technology (WebSockets) supports real-time data transfer, the application's behavior follows an asynchronous communication paradigm, similar to modern chat systems, rather than live video or voice transmissions.

To ensure performance and robustness, several non-functional requirements were implemented, including rapid responses during critical interactions, scalability to support multiple concurrent users, security through JWT-based authentication, XSS sanitization, permission management, and data protection. The interface was designed to be intuitive and accessible to users with varying levels of digital literacy, incorporating personalized educational content. The frontend employs reusable components, protected routing, and a rich text editor for content creation, while the backend integrates automatic API documentation (Swagger), global error handling, and support for development and production environments. The build process compiles frontend and backend into a single executable file, streamlining deployment.

The choice of technology stack (Angular + Spring Boot + MySQL) was motivated by its widespread adoption, extensive documentation, modularity, and efficient integration, enabling agile development and simplified maintenance. Alternative frameworks, such as Vaadin and JHipster, were considered; however, the selected combination proved to be more flexible and aligned with the project's objectives. Overall, FisioStroke addresses the growing demand for digital solutions that integrate personalized training, remote assessment, gamification, and clinical communication, thereby enhancing therapeutic continuity and patient experience, while also confronting challenges such as usability among elderly populations and integration with conventional healthcare services.

4 Results and discussion

4.1 Results

The platform successfully implements and demonstrates its main functionalities, including account creation with distinct profiles, JWT-based authentication, exercise plan management, asynchronous communication via WebSocket, remote monitoring, and a notification system. The security layer operated robustly, correctly generating and validating JWT tokens while returning appropriate error messages in cases of unauthorized access or attempts to retrieve non-existent data. On the frontend, Angular guards effectively restricted access to protected routes according to user roles, while the interceptor automatically injected the JWT token obtained during login into requests when required. Various common and customized components were conditionally rendered based on the user profile.

Data persistence operations were fast and efficient, with no failures or inconsistencies recorded during testing, and the system demonstrated stability with no critical bugs detected throughout the demonstrations. To further assess the platform's technical quality, automated tests were conducted using Lighthouse [13] across different modes (Snapshot, Timespan, and Navigation) and devices (Desktop and Mobile). The results revealed strong overall performance, with high scores in SEO and Best Practices, and acceptable performance on Desktop. However, in Mobile scenarios, the Navigation mode highlighted critical areas for improvement in performance, particularly regarding long loading times (First Contentful Paint and Largest Contentful Paint), insufficient text compression, and inefficient resource usage.

Table 1. Summary of Lighthouse results for login page (Desktop and Mobile)

Mode/Device	Performance	Accessibility	Best Practices	SEO
Desktop (Navigation)	90	100	78	100
Mobile (Navigation)	58	100	79	100
Desktop (Snapshot)	4/4	10/10	5/5	4/4
Mobile (Snapshot)	4/4	10/10	6/6	4/4
Desktop (Timespan)	10/10	–	6/8	–
Mobile (Timespan)	10/10	–	6/8	–

To provide context for the results, the following tables report the outcomes of the audits conducted using the Lighthouse tool, which assesses critical aspects of web applications, including performance, accessibility, adherence to best practices, and search engine optimization (SEO). Table 1 presents the evaluation

Table 2. Summary of Lighthouse results for home page (Desktop and Mobile)

Mode/Device	Performance	Accessibility	Best Practices	SEO
Desktop (Navigation)	86	88	78	100
Mobile (Navigation)	58	79	79	100
Desktop (Snapshot)	4/4	10/12	5/5	4/4
Mobile (Snapshot)	4/4	10/13	6/6	4/4
Desktop (Timespan)	10/10	–	6/8	–
Mobile (Timespan)	10/10	–	6/8	–

results for the login page and table 2 summarizes the results for the home page following successful user authentication.

4.2 Summary Evaluation

Overall, the system is functional and stable, with no critical bugs reported, and demonstrations in the development environment validated the intended interaction flows.

Performance was highly satisfactory, with fast response times, quick page loading, and REST calls within expected parameters, with no significant bottlenecks or failures identified. Usability tests showed intuitive navigation and a responsive design across devices. Although formal user testing has not yet been carried out, exploratory evaluations suggest an adequate user experience, with particular attention to accessibility for the target audience with motor impairments.

While the current version is complete, some opportunities for improvement were identified, including enhancing frontend reactivity with more advanced libraries and considering a future migration to a microservices architecture aligned with theoretical best practices. Further formal testing is also planned to validate the solution's effectiveness in real-world contexts.

4.3 Discussion

The development and evaluation of the FisioStroke platform demonstrate that digital rehabilitation solutions for post-stroke patients have significant potential to support home-based care, although they still face technical challenges. The Angular and Spring Boot-based architecture enabled the creation of a modular and scalable application; however, Lighthouse [13] tests revealed performance limitations on mobile devices, with high loading times, highlighting the need for further optimization to improve these metrics in the context of a PWA.

Accessibility and SEO results were positive, confirming that the platform is well adapted to its target audience, with a responsive interface that adjusts to different devices and user profiles. Features such as video recording with local storage—while storing only metadata in the database—enhance patient privacy and support proper exercise execution, while also reducing the need for large database capacity and lowering infrastructure costs. The use of a PIN to activate recordings helps prevent unauthorized videos from being added to exercise plans; however, because the physiotherapist has no remote access to videos stored on the patient's device, direct review of recorded material for future assessments is not possible.

Compared to other solutions, FisioStroke stands out for not requiring specialized hardware, increasing accessibility for home use. Nevertheless, the platform could benefit from incorporating advanced biometric monitoring functionalities, as implemented in more recent systems.

5 Conclusion

This work involved the development of a digital platform designed to support the physical rehabilitation of stroke patients in home environments. The platform was built as a Progressive Web Application leveraging robust and modern technologies - Angular for the frontend and Spring Boot for the backend - forming a layered client-server architecture with MVC pattern.

The contributions of this work align with solutions that promote treatment continuity, demonstrating the potential of technologies to support post-stroke recovery processes. The platform addresses a critical gap identified in the literature: the transition from clinical care to the home environment, providing treatment continuity. The video system ensures that patients are empowered to independently guide themselves in continuing the rehabilitation work started in the clinical environment.

We can point out some limitations to the current phase of our work. Firstly, comprehensive acceptance testing with end-users has not yet been conducted. This is a crucial step for a complete validation of the user experience (UX) and user interface (UI) and for gathering direct feedback on the platform's real-world usability and effectiveness. Secondly, while functional, the performance indicators of the platform, particularly in mobile environments, require further optimization. Thirdly, it is important to recognize that the platform does not implement objective validation of exercise execution by users. Currently, the platform does not use any mechanism to validate or analyze the execution of exercises, particularly through the use of artificial intelligence or computer vision.

Future work should focus on three main directions. First, it is essential to conduct acceptance testing with healthcare partners, including validation with the Ethics Committee, to demonstrate the platform's effectiveness in real-world contexts and obtain approval for use in hospital environments. Second, mobile performance optimization should be prioritized to resolve the loading issues identified in Lighthouse tests and improve user experience, including caching strategies to accelerate server responses. Third, feature expansion should involve the integration of biometric sensors and the implementation of artificial intelligence systems, including computer vision algorithms, to enable objective measurements of exercise execution and physiological parameters, as well as real-time validation and feedback on the technical correctness of movements. These improvements, combined with the existing modular architecture, position the platform as a solid foundation for the future development of digital rehabilitation solutions.

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