Design of a Digital Solution to Motivate Older Adults to Follow Cognitive and Physical Training for an Active and Healthy Ageing

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Abstract: Active and healthy ageing depends on maintaining physical and cognitive activity, but it is still challenging to motivate older adults to participate in regular training. This paper describes the iterative design and evaluation of a digital platform for increasing older adults' motivation to perform physical and cognitive exercises. The digital solution was designed and evaluated in four iterations with a total of 13 older adults. The first stage focused on identifying effective communication methods, including different formats of instructional delivery and feedback, as well as tone. The second stage explored the combination of physical activity with cognitively stimulating activities, such as brain games, sport, and hobbies, to find the most motivating combinations. The final stage developed the prototype further by integrating motivational elements into one coherent design, emphasizing clarity, guidance, and user agency. The final evaluation reviewed the overall design, including the importance of adaptive systems that dynamically adjust the difficulty level to align with users' physical and cognitive abilities to increase motivation. This study contributes to the growing field of participatory design within digital health interventions, aligning with best practices that emphasize the need for dynamic user involvement in all stages of development.

1 INTRODUCTION

Europe's aging population is increasing, leading to health and social challenges such as reduced independence, higher disease incidence, and increased healthcare costs (Bernì et al., 2023). Promoting active living through combined physical and cognitive training can mitigate these issues, enhancing well-being and delaying age-related decline (Chan et al., 2020; Sanchini et al., 2022).

While such interventions are effective, they often require specialized resources that are not always accessible. Information and communication technology (ICT) offers a scalable solution, enabling remote delivery of training programs via digital platforms. These tools integrate physical and cognitive exercises through sequential, simultaneous, or gamified approaches, making training more engaging and accessible (Vozzi et al., 2022; Gavelin et al., 2021).

The ACTIVAS project addresses these challenges by integrating a tailored physical exercise module into COGWEB, an existing cognitive training platform (Baptista et al., 2023; Cruz et al., 2014). Following guidelines for progression and individualization, ACTIVAS offers functional,

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aerobic, muscle-strengthening, and balance exercises to support older adults at risk of decline.

Despite its potential, prior research highlighted motivation as a key barrier to engagement. This study presents the redesign of the digital platform, focusing on enhancing user motivation through a participatory design approach, where users and stakeholders were engaged in an iterative process of prototype evaluation and improvement. The final evaluation results offer insights into usability and engagement, informing future improvements.

2 METHODS

The study followed a user-centered iterative design process across four stages to refine and validate the digital platform aimed at motivating older adults to engage in cognitive and physical training.

Each iteration involved the development of a digital platform prototype with specific elements, and tested a specific hypothesis related to the motivational features of the prototype, assessing the potential impact of various design components on user engagement.

Additionally, each session included a conversation with participants to explore potential barriers to engaging in remote physical exercises, as well as factors that could enhance their motivation, which provided insights to shape the subsequent prototype.

2.1 Iteration 1: Testing the Interaction

The first iteration aimed to evaluate the communication features of the platform, specifically identifying which methods of interaction, instruction delivery, and feedback were most motivating for users. This test focused on the hypothesis that effective communication and interaction methods between the user and the platform are essential for enhancing user motivation. An interactive prototype of the platform was created using mockups (Figure 1).

A simulated session consisted of three exercises, each designed to test different approaches to delivering instructions, feedback, and tone of communication. In this session, the first exercise utilized a step-by-step explanation with 2D animations, a neutral tone, and an audio feedback mechanism, allowing participants to record their responses. The second exercise was led by a dynamic gym instructor presented in a single video format, enhanced by background music to encourage engagement. The third exercise combined a step-by-step explanation with a video of a physiotherapist and supportive text, using a kind yet scientific tone to emphasize the health benefits and necessary information. Figure 2 illustrates the setup for this test.

During the procedure, participants were asked to simulate the exercise session by following the on-screen instructions while engaging in a think-aloud protocol, voicing their actions and thoughts to provide real-time feedback. They were then asked to evaluate each communication approach, assessing which methods of instruction delivery, feedback, and communication tone they found most motivating and explaining the reasons behind each preference.

Figure 1: Prototype mock-ups from Iteration 1 representing the three exercises shown during the test.

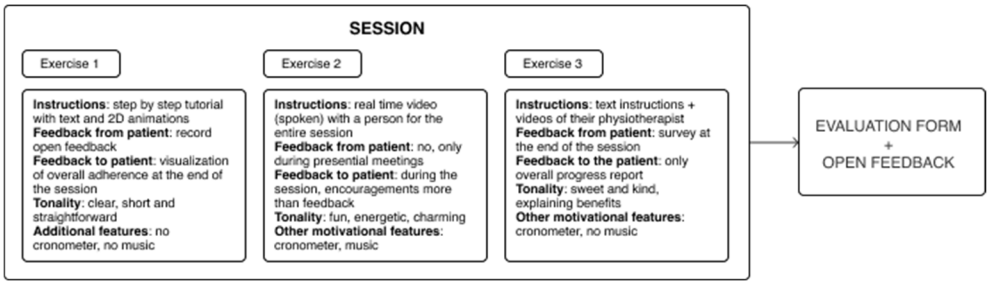

Figure 2: Set-up for the Iteration 1 test.

2.2 Iteration 2: Integrating Cognitive and Physical Activities

The second iteration aimed to test the hypothesis that pairing physical exercise with an additional engaging cognitive activity would make the exercise more motivating compared to performing the exercises alone. This iteration was structured to present three different types of activities alongside physical exercises: games (including cognitive tasks, quizzes, and riddles), sports (such as tennis, baseball, bowling, and dancing), and hobby-based activities (like reading, painting, or playing music). An unaccompanied physical exercise was also included to assess whether this added element truly enhanced motivation. The goal was to determine which of these activity categories participants found most engaging and why, while also assessing whether users could successfully perform both the physical and cognitive tasks simultaneously. The participants were asked to rate the exercise's engagement, enjoyment, and ease of understanding on a Likert scale from 1 to 5. A score of '1' indicated 'not engaging or enjoyable at all' or 'not easy at all,' while '5' represented 'very engaging and enjoyable' or 'very easy to understand and perform'. These ratings provided a framework for identifying which activity types resonated most with participants and clarified their preferences.

The test setup involved a session consisting of 11 tasks, each integrating a physical exercise or an activity from one of the categories, as shown in Figure 3. The tasks were divided into (4) game tasks, (4) sport-based tasks, (3) hobby-based tasks, and (1) physical exercise alone. The prototype for this test session, along with detailed descriptions of each task, is illustrated in Figure 4.

Both physical and cognitive tasks were kept at a low difficulty level to ensure that participants of varying skills and abilities could easily perform them. At the end of the session, participants were asked to indicate their preferred category and provide feedback on their experiences, particularly in terms of motivation.

Figure 3: Set-up for the Iteration 2 test.

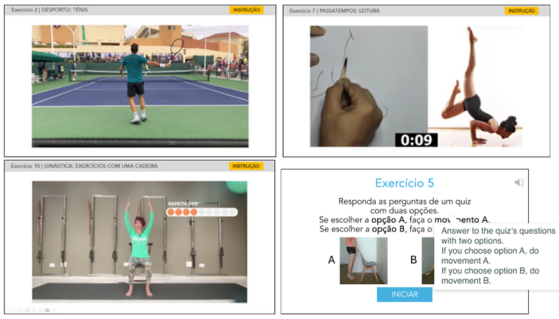

Figure 4: Prototype screens from Iteration 2 representing the four kind of exercises shown during the test.

2.3 Iteration 3: Converging the Insights into One Concept

The third iteration aimed to converge and test the most effective motivational elements identified in previous iterations, examining how they could be applied in a cohesive design, integrating aspects of communication and interaction with the activities that were found to enhance motivation, and assessing how these elements could be combined in an actual exercise session. This iteration also focused on gathering feedback to refine the final design.

Although the final design featured various exercise activities, this test was designed to refine the integration of communication, feedback, and activity engagement within one exercise to ensure its effectiveness. The prototype, shown in Figure 5, simulated a session that included the following components:

- An introduction outlining essential information, such as exercise details, duration, required materials, and expected benefits
- Step-by-step instructions for the exercise, supported by examples
- The exercise itself

The chosen exercise for this prototype was "Remember the Sequence," a game introduced in the second iteration. In this game, users watched videos showing a sequence of movements, each new video adding an additional movement to the previous sequence. After each video, users were asked to repeat the sequence from memory, with the task becoming progressively more challenging as the number of movements increased. Figure 6 illustrates the test setup. After completing the session, participants were asked to provide open feedback on the integration of motivational elements and the overall concept and also to rate the prototype based on how well it embodied motivational qualities

identified from previous iterations: engaging and guiding, along with a new quality introduced in this phase, in control. Participants rated each aspect on a Likert scale from 1 to 5, with '1' indicating 'not at all' and '5' indicating 'very much'.

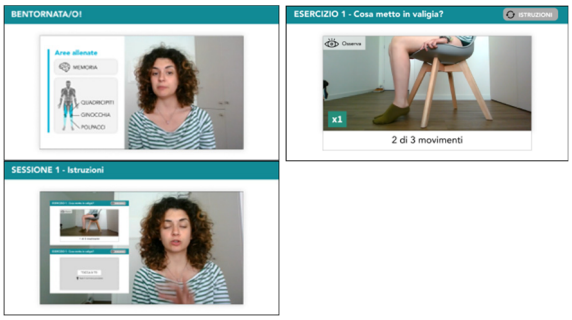

Figure 5. Prototype screens from Iteration 3 representing the three components of the session.

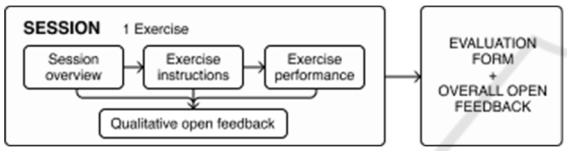

Figure 6. Set-up for the Iteration 3 test.

2.4 Final Evaluation: Testing the Complete Platform

The final evaluation involved testing the ultimate version of the platform prototype. As part of the evaluation to understand whether the design successfully motivated users to perform the exercises, the evaluation also aimed to uncover critical aspects related to designing digital platforms for older adults, particularly those with potential cognitive impairments. Special attention was given to ensuring that the instructions were clear, and the tasks were easily understood and executed without confusion.

The test setup, shown in Figure 7, involved a session with four tasks that combined cognitive activities with corresponding physical exercises.

To accommodate different skill levels, two difficulty settings were incorporated into both cognitive and physical tasks. This approach ensured that participants encountered an appropriate level of challenge, avoiding boredom from tasks that were too easy or frustration from tasks that were too difficult—following the principles of Flow Theory (Csíkszentmihályi, 1975).

Participants followed the tasks while verbalizing their thoughts, and their actions were closely observed to gain insights into potential errors or patterns of behaviour. After completing the session, participants provided open feedback on the overall experience and rated a Likert scale ranging from 1 to 5, focusing on three factors: engagement, challenge, and clarity.

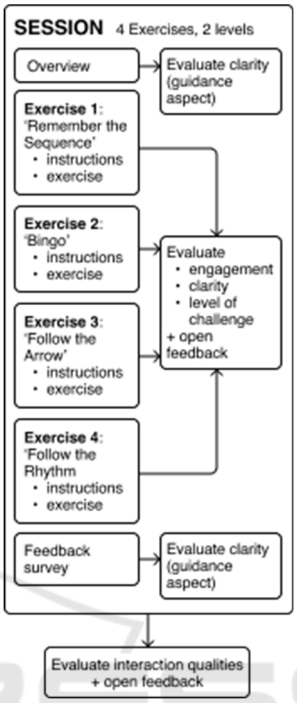

Figure 7. Set-up for the final evaluation test.

3 RESULTS

This study included a total of 13 participants across four iterations. In the first iteration, three participants (two females and one male) with a mean age of 74.33 years (SD = 6.5) were included. The participants had varying levels of physical activity: one with low, one with moderate, and one with high levels. Two participants were cognitively healthy older adults, while one had a diagnosis of Alzheimer's disease at its first stage and was a COGWEB user.

In the second iteration, three participants (one female and two males) with a mean age of 61.7 years (SD = 4.2) participated. Their physical activity levels were distributed as follows: one engaged in moderate activity, one in low activity, and one did not engage in any physical activity. Two participants were cognitively healthy older adults, and one had experienced a stroke in 2010.

In the third iteration, three participants (two females and one male) with a mean age of 66.3 years (SD = 5.8) took part. Among them, one engaged in high levels of physical activity, one in moderate activity, and one did not engage in any physical

activity. Two participants were cognitively healthy, while one had a stroke in 1988.

The final iteration consisted of the final evaluation, with four participants aged 51 to 74 years (mean age = 61.5, SD = 9.7). These participants had either moderate or low physical activity levels. Three participants were cognitively healthy older adults, while one had a brain injury and was a COGWEB user.

3.1 Iteration 1: Testing the Interaction

The results of the first test iteration revealed key preferences and needs among participants regarding the platform's communication features. Participants expressed a clear preference for instructions delivered by a real person, ideally a familiar physiotherapist, as this enhanced trust and credibility. As one participant stated, *"I like the way she talks; she is nice, clear, and slow. I can follow her and do the exercises while she explains".* Video instructions were generally preferred over step-by-step formats, though participants appreciated visual animations with concise explanations for their clarity.

Instructions were most effective when straightforward, avoiding abstract language or excessive detail, and when paired with an overview that included necessary materials and session duration. Participants favoured a tone that was kind but concise, as opposed to overly energetic encouragement. They also responded positively to a sense of accomplishment from progress-tracking features, and found the feedback modalities more clear and understandable when conveyed with a diversity of media, such as visuals paired with text and graphics. Simple, closed questions were easier to process than open-ended prompts, highlighting the need for clear guidance using multimedia formats (e.g., voice, images, and video) to accommodate potential sensory impairments. Additionally, they preferred linear navigation over screens requiring multiple selections, and found practical information about exercise benefits to be more motivating than scientific explanations.

This feedback provided insights into the communication strategies that most effectively encourage users to engage in physical exercises within the platform.

3.2 Iteration 2: Integrating Cognitive and Physical Activities

Results showed that exercises combining physical exercise with cognitive tasks, like bingo paired with movement, received the highest average scores in the 'engaging and enjoyable' category, suggesting that integrating mental challenges alongside physical activity offered a more motivating experience compared to exercises alone. Conversely, purely physical exercises were rated highly only by participants with active lifestyles, while sedentary or less active individuals scored these activities lower, indicating the need for additional interactive elements to sustain engagement for these users.

Activities simulating participants' hobbies, such as mimicking tasks while performing movements, received lower scores in 'ease of understanding,' reflecting the difficulty participants encountered when required to focus on two simultaneous tasks. As one participant noted, "*Now I find the bingo fun and easy enough. But when I was recovering from the stroke, I would have never been able. It's important that this exercise is adapted for every condition*". The quantitative insights from this evaluation, detailed in Figure 8, highlight that participants rated exercises incorporating cognitive challenges, interactive elements, and a combination of physical movement with non-physical tasks as the most engaging (exercises 5, 6, 7 and 10). Conversely, exercises perceived as less engaging, typically those relying on simple imitation or tasks, deemed too easy received lower scores (exercises 2, 3, 8, 9 and 11). Despite this variation in engagement, most exercises scored well (>3) in terms of ease of understanding and clarity, with the exceptions of exercise 8 and exercise 10 which received comparatively lower scores in these categories.

These findings informed the refinement of the platform's design.

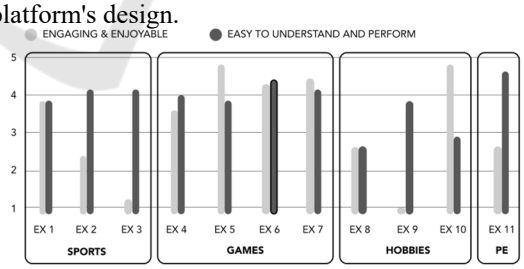

Figure 8. Bar chart representing the average participants' score for each exercise.

3.3 Iteration 3: Converging the Insights into One Concept

After integrating the insights from the steps above into one prototype exercise, users scored the prototype highest in control (5/5) and guiding (4.5/5) indicating that participants felt well-supported and capable of following and performing the exercises

correctly. Participants appreciated the clear overview, the use of multimedia formats such as words, images, and animations during explanations, and the sample examples provided. As one participant mentioned, "*The instructions were clear to me only when the example was provided. I understood in that moment what I had to do*". However, the prototype scored low in engagement (2/5), with feedback suggesting that the physical exercises were too easy for most users, making them less stimulating and engaging. Participants expressed a desire for more challenging physical activities and emphasized the importance of tailoring exercise difficulty to individual abilities: "*I like the idea of playing with physical exercises, but these ones are too easy. I'd like more challenging exercises*".

The insights and ratings from this test highlight the value of integrating cognitive challenges with varied and adequately challenging physical activities. The feedback further suggests that instructional clarity should remain a priority to maintain a sense of control for users at different ability levels. These insights informed the final design's refinement. Quantitative results can be viewed in Figure 9.

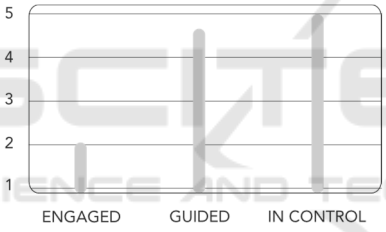

Figure 9. Bar chart representing the average scores given by participants' score for each quality.

3.4 Final Evaluation: Testing the Complete Platform

The final prototype design, resulting from the four iterations and shown in Figure 10, incorporates a dual-task component featuring a series of cognitive tasks in the form of exergaming, requiring physical responses from users. Each session begins with an overview provided by the patient's physiotherapist, who remains present throughout to guide the exercises. Clear and instructive videos accompany each activity, ensuring ease of understanding.

The sessions include four games designed to target specific cognitive and physical skills:

1. Remember the Sequence: Patients observe and memorize a sequence of movements displayed on the screen, then replicate them. As the sequence lengthens, the cognitive and physical challenges increase, enhancing memory and coordination.
2. Bingo: This game combines traditional bingo with physical exercise, focusing on attention and processing speed. Patients interact with a digital bingo table, performing a specific movement whenever a called number matches one on their table.
3. Follow the Arrow: Patients respond to arrows displayed on the screen, each indicating a specific movement. As arrows light up, users perform the corresponding actions, sharpening executive functions and processing speed.
4. Follow the Rhythm: Patients tap their feet in rhythm with a piano melody, guided by visual cues—right foot for green keys and left foot for red keys. This activity improves coordination and rhythm while supporting executive function development.

At the end of each session, patients provide feedback through a survey, enabling personalized adjustments to future exercises. A progress report summarizes their activities, celebrating achievements and identifying areas for improvement.

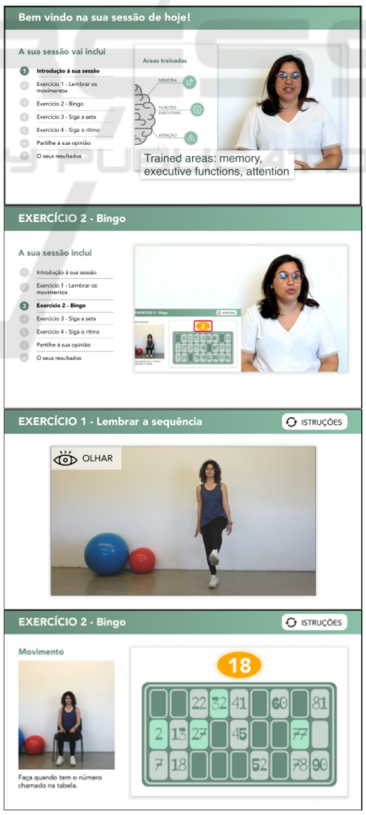

Figure 10. Screens from the final prototype design.

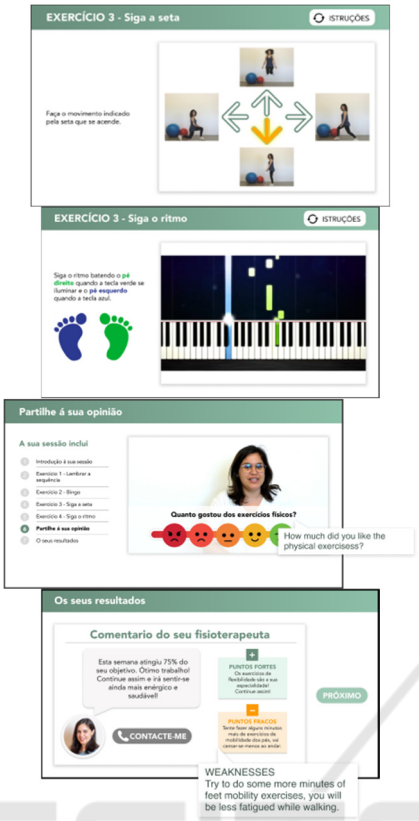

Figure 10. Screens from the final prototype design (cont.).

The final evaluation's results, illustrated in Figure 11, indicated that participants rated the concept highly for both engagement (mean of 4,75 out of 5) and guiding (mean of 4.68 out of 5), reflecting a generally positive experience with the platform. However, the average score for clarity was notably lower (mean of 4.01 out of 5), indicating room for improvement in effectively conveying instructions to ensure participants fully understood the tasks at hand. Despite some initial confusion leading to mistakes, participants were able to correct these errors by reviewing the instructions or during the exercise itself. One participant noted, "*I'd love it if this was implemented into COGWEB®. I'd feel even prouder to complete the sessions if I am also improving my physical abilities besides the cognitive ones*", highlighting the value of integrating physical and cognitive tasks.

The combination of physical exercises and cognitive challenges was particularly well-received, as participants reported a satisfactory level of engagement where the difficulty level matched their abilities, fostering eagerness to continue. The presence of a physiotherapist in the instructional videos further enhanced participants' sense of guidance, trust, and credibility. Although some usability issues were identified, such as unclear animations and repetitive movements in specific exercises, these did not significantly detract from the overall positive feedback. The findings suggest that the final design effectively embodies the motivational qualities, providing a dual challenge that could make physical exercise more appealing to a broader audience, especially for sedentary users who may be motivated by the cognitive elements.

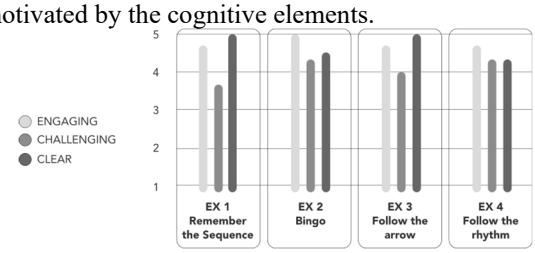

Figure 11. Bar chart representing the average participants' score for each exercise considering engagement, challenge and clarity factors.

4 DISCUSSION

The findings from this study highlight several key insights for designing digital solutions aimed at motivating older adults to engage in physical and cognitive training for active and healthy ageing. Across all iterations, engagement was identified as a critical factor for sustained participation in the platform. Activities combining physical and cognitive challenges, such as movement-based bingo, were consistently rated as the most enjoyable and motivating. This supports existing research that shows gamified elements and dual-task activities can enhance motivation in older adults by creating a sense of purpose and enjoyment during exercise (Lister et al. 2014). However, purely physical exercises received mixed responses, with more active participants finding them engaging while sedentary users required additional interactive elements.

A key finding of the study was the positive reception of exercises that integrated physical and cognitive tasks. Participants valued the dual challenge, which not only made the exercises more enjoyable but also contributed to a sense of accomplishment. This aligns with evidence suggesting that combining physical and cognitive training can have synergistic benefits for brain health and overall well-being in older adults (Eggenberger et al. 2015).

The user's feedback indicates that these dual-task exercises may be particularly effective for sedentary

individuals, who might be more motivated by cognitive aspects than by physical activity alone. However, it is essential to ensure that such tasks remain accessible and understandable, especially for users with lower baseline capabilities or cognitive impairments.

Clear and concise instructions were also essential to ensure participants could easily understand and follow the exercises. Feedback from all iterations emphasized the importance of using multimedia formats, such as videos, images, and animations, to accommodate sensory impairments and different learning preferences. Participants consistently reported that providing examples of the exercises enhanced their comprehension and confidence, which is consistent with the results of Yang et al. (2022) study.

However, the lower clarity ratings during the final evaluation suggest room for improvement in conveying instructions. Issues such as unclear animations and overly simplistic instructions for certain tasks may hinder user comprehension, particularly for older adults with cognitive impairments. This reinforces the need for iterative usability testing to refine the instructional design, ensuring accessibility and ease of use, which will be conducted in future work.

The final iteration also demonstrated that participants were most motivated when the difficulty level of activities aligned with their abilities, influencing positively their level of engagement. This finding underscores the importance of adaptive systems that dynamically adjust the challenge level based on the user's physical and cognitive abilities to maintain engagement over time.

The study revealed significant variability in preferences and capabilities among participants, highlighting the need for personalized approaches. Participants expressed a strong preference for tailored exercises, both in terms of physical and cognitive difficulty. The variability in engagement levels observed in this study, particularly between more active and sedentary participants, suggests that a one-size-fits-all approach is insufficient. Instead, adaptive difficulty levels and tailored content are critical for sustaining motivation. Personalization and adaptation emerged as a key requirement in our study, reflecting broader trends in the literature (Laukka et. Al. 2024).

The inclusion of physiotherapists in the platform's instructional videos enhanced trust and credibility, further motivating participants to engage with the program. The same was verified in the studies of Boucher & Railer (2024) and Wiśniewska et.al (2021). This study also contributes to the growing literature on participatory design in digital health solutions. The iterative design process used in this study aligns with best practices outlined by Sanders & Stappers (2020), which stress the importance of actively involving users and stakeholders throughout every phase of product development. By addressing usability and engagement issues through iterative refinement, this study demonstrates how participatory design methods can lead to solutions that meet the specific needs of older adults. Despite these contributions, several limitations should be noted. The small group of participants limits the generalizability of the findings, and most participants were cognitively healthy, while the platform component is intended for integration into a software system aimed at individuals with cognitive impairments. Additionally, all tests were conducted face-to-face, which may have positively influenced engagement and motivation. These conditions differ from the intended remote use of the platform, where user interaction dynamics could vary significantly. Future studies should address these limitations by including a larger and more diverse sample, incorporating users with varying degrees of cognitive impairment, and testing the platform in a remote setting.

5 CONCLUSIONS

This study demonstrates the feasibility and potential benefits of a digital platform designed to motivate older adults to engage in cognitive and physical training. The iterative design process revealed several key principles for creating an effective and engaging solution, including clear, concise, and multimodal instructions, tailored exercises and adaptive difficulty levels, and the inclusion of instructions provided by trusted professionals, such as physiotherapists. While the platform showed promise in fostering engagement and motivation, further improvements are needed to address usability issues and refine the design. Future work should focus on validating the platform's effectiveness, as well as exploring long-term adherence. The study contributes to the growing field of digital health interventions for ageing populations and provides a foundation for developing solutions that promote active and healthy ageing through combined cognitive and physical training.

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