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# Rehabilitation program for elderly to improve physical and cognitive activities using Nintendo Switch: A feasibility study in care settings

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ABSTRACT

This study aimed to evaluate the usability of the Nintendo Switch for elderly individuals, including ease of use, understanding of the games, and the user interface, as well as to assess the engagement and adherence levels of elderly participants in the program. Over eight weeks, 14 elderly individuals participated in rehabilitation sessions using exergames, utilizing the Nintendo Switch twice a week. Usability was assessed through the System Usability Scale, and intrinsic motivation was measured using the Intrinsic Motivation Inventory. The participants, with an average age of 81.1 years, showed high inherent motivation (IMIp: 82.2 ± 9.9), but the usability of the Nintendo Switch was considered below average (SUS: 52.9 ± 14.1). Despite the high motivation, the usability of the Nintendo Switch was not ideal, although participants expressed enjoyment and interest in the activities. The need for prior training and integration on this technology, tailored to this age group and individually adjusted, is emphasized.

**Key Practice Points**

* It is essential to provide personalized training and guidance to elderly individuals before introducing them to new technologies such as the Nintendo Switch. This training should be adapted to their needs to improve usability and ensure more effective engagement with exergames.

* The older people participants showed high intrinsic motivation to participate in the exergames, even though they rated the usability of the Nintendo Switch as below ideal. This suggests that with improvements in interface design and user support, these interventions could be more successful.

* Given the positive engagement and potential health benefits observed, exergames should be considered for regular integration into the daily routines of older people. This could promote active ageing and improve mobility, coordination, and cognitive

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function in this population.

## 1. Introduction

Exergames are a type of video game that incorporates physical exercise. Unlike traditional sedentary games, exergames encourage players to engage in physical movement. This approach has been around for approximately 40 years. Still, it has gained popularity recently due to its ability to make exercise more appealing, enjoyable, and engaging, offering a refreshing alternative to monotonous workout routines (Silva et al., 2021). These games can utilize various technologies, including wearable devices with sensors, motion-tracking systems, interactive mats, and touchscreens, providing a wide range of interactive and playful experiences between the game environment and the players (Born et al., 2021).

Exergames are also known as active video games, active games, interactive games, exertion games, or motion-controlled video games. These are games in which the effort-based interface enables an enriched player experience (Vaghetti et al., 2018).

In older adults, digital technologies significantly impact rehabilitation processes and health promotion, with implications for their quality of life (Brandão et al., 2017). Implementing these resources can be an appropriate method to promote active, healthy, and independent ageing. Exergames used by elderly individuals improve overall mobility, coordination, cognitive ability, socialization, and spontaneity. Several studies recommend using exergames to complement conventional therapeutic programs (Rüth et al., 2023; CS Fernandes et al., 2022; Thalmann et al., 2021; Hernandez-Martinez et al., 2024).

Physical inactivity, often referred to as the silent killer, represents a serious global public health concern (Ijaz et al., 2020), being the fourth leading cause of death worldwide and responsible for approximately 3.2 million deaths annually (Warburton & Bredin, 2018). This contributes to immobility and affects all bodily systems, including the integumentary, cardiorespiratory, genitourinary, gastrointestinal, sensory, cognitive, and musculoskeletal systems (Guedes et al., 2018). As people age, chronic diseases tend to emerge, leading to increased physical inactivity (Mandili et al., 2022), which highlights the need for innovative rehabilitation programs, such as those incorporating exergames (Gschwind et al., 2015). Promoting physical activity is, therefore, essential to improve this vulnerable population's overall health and quality of life.

Studies show that adequate physical activity levels, even light or moderate, are associated with significant health benefits, including improved muscle strength, motor coordination, and cognition (Cunningham et al., 2020)'. In the study by the authors (Cunningham et al., 2020)' it was concluded that physically active older adults have a lower risk of mortality from cardiovascular diseases, breast and prostate cancer, fractures, falls, immobility, and disability in performing daily living activities, as well as a reduced risk of cognitive decline, dementia, Alzheimer's disease, and depression. The same study describes that these older adults experience healthier ageing due to improved quality of life and greater cognitive capacity. However, many older adults face barriers to conventional exercise due to physical limitations, lack of motivation, or the monotony of traditional workout routines.

In this context, exergames — video games incorporating physical exercise — emerge as an innovative solution to overcome these barriers. These games enable activities ranging from light to vigorous, including movements that promote muscle strengthening and coordination, making exercise more engaging and accessible (Silva et al., 2021; Born et al., 2021)' The literature suggests that exergames can complement conventional therapeutic programs, offering a dynamic and interactive alternative to improve mobility, cognition, and socialization among older adults (Rüth et al., 2023; CS Fernandes et al., 2022; Thalmann et al., 2021; Hernandez-Martinez et al., 2024)' The game scenarios in exergames are typically appealing, which promotes adherence among older adults (Leal et al., 2023). However, some elderly individuals resist using these games (Mogavi et al., 2024). Given that the technical and technological knowledge of today's elderly population is often still limited, there is a need for games with simple setups, stable connections, and intuitive interaction (Adcock et al., 2020). As the Nintendo Switch is a relatively recent exergame platform, it becomes necessary to evaluate its usability for elderly individuals, including ease of use, understanding of the games, and user interface, as well as to assess the engagement and adherence levels of elderly participants in the program.

## 2. Methods

### 2.1. Desenho do estudo

This research constituted the project's final phase, "Exergames in Promoting Autonomy Among the Elderly." This feasibility study was preceded by a quasi-experimental study with a control group, the protocol for which is available at https://osf.io/7z5ju/ (DOI 10.17605/OSF.IO/7Z5JU). The primary objective of that study was to evaluate the effectiveness of Nintendo Switch® exergames in promoting rehabilitation for older adults.

The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist (von Elm et al., 2008) was followed to ensure the methodological quality of this study.

### 2.2. Participants

All participants were residents of a nursing home located in northern Portugal. The sample participated exclusively in the exercises implemented by the program described in this study. To be included, participants had to meet the following criteria: be 60 years or older; be institutionalized in Residential Structures for the Elderly (ERPI); present a risk of falling (with a POMA score between 19 and 28 points); and voluntarily agree to participate in the study by signing an informed consent form. A non-probabilistic convenience sampling technique was used for sample selection.

### 2.3. Intervention

After selecting participants, the intervention began and lasted for eight weeks, with two weekly sessions of 60 min each to maximize the program's benefits. None of the participants had prior experience with the Nintendo Switch®. All sessions were conducted in a safe environment. The intervention took place in the institution's gym room, which was chosen as the location for the activities. All participants were available when the research team visited the elderly institution to implement the program.

The Nintendo Switch®, a console released in 2017, offers more versatile games than previous versions, featuring superior resolution and a more compact design. Additionally, the console has infrared cameras built into the "Joy-Con" controllers, capable of capturing hand movements (Cuesta-Gómez et al., 2022). The "Joy-Con" controllers are wireless, and thanks to the integrated infrared motion sensors and a 54-inch monitor, immersive avatars were displayed in the video games. Four "Joy-Con" controllers were used simultaneously during the intervention.

Before each session, the use of the console and the corresponding game was thoroughly explained to the participants. After this introduction, a warm-up was conducted, consisting of a series of exercises to prepare the muscles and joints for the more intense activity.

As shown in Fig. 1, Nintendo Switch® Sports games were used during the sessions. From the 1st to the 5th session, participants played Bowling (which requires shoulder flexion-extension, elbow flexion-extension, and hand muscle strength to press the button with the second finger) – the player simulates the motion of throwing a bowling ball using the controller, aiming to knock down the pins on the screen, and Badminton

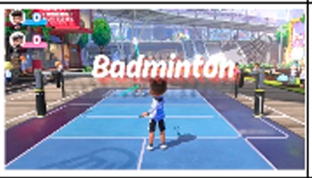
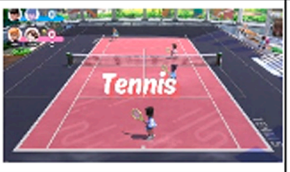
| Rehabilitation Program | | | | |
|---|---|---|---|---|
| | 1st to 5th session | 1st to 5th session | 6th to 16th session | 11th to 16th session |
| Game | Nintendo Switch Sport Bowling | Nintendo Switch Sport Badminton | Nintendo Switch Sport Badminton | Nintendo Switch Sport Volleyball |
| |   |   |   |   |
| | Requires shoulder flexion-extension, elbow flexion-extension, and muscle strength in the hand to press the button with the second finger | Involving shoulder flexion-extension, elbow abduction-adduction, wrist flexion-extension, and forearm supination-pronation | Requiring lower limb movements such as flexion-extension, shoulder abduction-adduction, elbow flexion-extension, and forearm pronation-supination, in addition to testing the player's strength and reflexes | Requiring shoulder flexion-extension and abduction-adduction, elbow flexion-extension, wrist flexion-extension, and forearm supination-pronation |
| Time | 20 min | 20 min | 40 min (6th to 10th session)<br>20 min (11th to 16th session) | 20 min |
| Objectives | – Increased muscular strength<br>– Improved balance<br>– Minimization of the effects of cardiovascular and musculoskeletal immobility<br>– Enhanced abdominal wall mobility<br>– Improves fine motor skills | – Maintaining proper body posture<br>– Control, coordination, and balance<br>– Muscular strengthening of the lower limbs<br>– Improves fine motor skills | – Control, coordination, and balance.<br>– Reduction of pulmonary complications (atelectasis, pneumonia, respiratory failure, pulmonary thromboembolism).<br>– Improves fine motor skills | – Increased muscular strength<br>– Improved balance<br>– Minimizing the effects of immobility on the cardiovascular and musculoskeletal systems<br>– Greater mobility of the abdominal and thoracic walls.<br>– Improves fine motor skills |

**Fig. 1.** Rehabilitation Program.

(which involves shoulder flexion-extension, elbow abduction-adduction, wrist flexion-extension, and forearm supination-pronation) – the player moves the controller to simulate the motion of a racket, hitting the shuttlecock to the opposite side.

From the 6th to the 10th session, Tennis was played (which requires movements of the lower limbs, such as flexion-extension, shoulder abduction-adduction, elbow flexion-extension, and forearm pronation-supination, while also testing the player's strength and reflexes). The player simulates the motion of a tennis racket to return the ball to the opponent.

From the 11th to the 16th session, Tennis and Volleyball were played. Volleyball requires shoulder flexion-extension, abduction-adduction, elbow flexion-extension, wrist flexion-extension, and forearm supination-pronation – the controller is used to simulate typical volleyball movements like serving, passing, setting, and spiking the ball.

At the end of each session, stretching exercises were performed.

Some potential technological limitations related to using the Nintendo Switch® console and the "Joy-Con" controllers were identified and addressed during the intervention. The controllers were calibrated before each session to ensure the accuracy of movements. If a controller failed to detect movements or lost connection, the session was temporarily paused to resolve the issue.

Additionally, technical support was available during all sessions to intervene promptly in case of difficulties, such as problems syncing the "Joy-Con" controllers to the console or visualizing the avatars on the monitor. This measure was crucial in minimizing interruptions and ensuring the continuity of activities. To maintain session consistency, any time lost due to technical problems was compensated by extending the session duration as necessary.

These precautions were essential to preserving the quality and effectiveness of the intervention, minimizing the impact of technological limitations on participants' engagement and outcomes.

During the intervention, participants engaged in structured exergaming activities across 16 sessions. Usability and motivation were evaluated only after the intervention as part of a single-session assessment. While this approach was chosen to ensure minimal disruption and maintain participant comfort, it limits the ability to evaluate how user perceptions evolved.

All sessions were conducted in a dedicated gym room at the institution, specifically chosen for its spaciousness and accessibility. The room was well-lit, with adjustable lighting optimized to ensure clear screen visibility for all participants. They were held during quieter times to minimise distractions, and non-participating staff or observers were not permitted in the room during gameplay. All sessions occurred at consistent times of day to reduce variability in participant energy levels or alertness.

### 2.4. Data collection

Data collection took place from January to March 2023. Before the

start of the program implementation, a sociodemographic questionnaire was administered. The instruments used to assess efficiency, effectiveness, satisfaction, and intrinsic motivation for gameplay, which were used to analyze the objectives of this study, were administered to participants after the 16 sessions.

For the assessment of efficiency, effectiveness, and satisfaction with the use of the games, the System Usability Scale (SUS) was employed. The Intrinsic Motivation Inventory (IMI) was chosen to evaluate the participants' intrinsic motivation for using the game.

Regarding sociodemographic data, information was collected on age, duration of institutionalization, education level, gender, and marital status.

The choice to carry out usability and motivation assessments in one session after all intervention sessions aimed to lessen the mental and physical strain on participants, primarily elderly people with different levels of physical capability and technology knowledge. This method focused on making it easier for participants and ensuring that the assessment did not interfere with the intervention sessions or influence participant retention. Nonetheless, this approach is recognized as a possible drawback.

This study aimed to assess the feasibility of using Nintendo Switch® exergames as a rehabilitation tool for elderly individuals. As such, usability and motivation were measured as cumulative outcomes at the end of the intervention rather than being disaggregated by game type. This decision was made to maintain simplicity in data collection, given the pilot nature of the study and the limited sample size.

### 2.4. Data analysis

Descriptive analysis of the results was performed using the Statistical Package for the Social Sciences (SPSS) software, version 29.0 (IBM, Armonk, NY, USA). Even though regular assessments were not done, participant feedback in sessions shows they felt their experiences improved. For instance, comments like "I'm doing better today than last week" and "This is really fun" suggest they felt more comfortable and engaged over time. This casual feedback points to the possible advantages of observing participants' experiences in a more organized way in upcoming studies.

### 2.5. Ethical considerations

This research project was carried out using the ethical principles for medical studies involving humans, established at the 18th World Medical Association General Assembly in Helsinki. All participants in this study participated voluntarily, and all data collected was treated with confidentiality. The participants were free to discontinue their participation in the study at any time and without giving a reason. All participants received written and oral information regarding the study and gave written consent to participate. Given the limited knowledge concerning the potential adverse effects of MTIs as part of CF care, no passive joint mobilisation with impulse was included in this study. The researchers monitored potential adverse impact or discomfort experienced by participants during the sessions. If any participant showed signs of discomfort or changes in their condition, they were invited to discontinue the intervention. This project received approval from the Ethics Committee of the Unidade Local de Saúde do Alto Minho (no. 72/2022).

## 3. Results

### 3.1. Participant characterization

Fourteen institutionalized participants were included in the analysis, 4 (28.6 %) male and 10 (71.4 %) female, with a mean age of 81.1 ± 7.2 years. Most participants were widowed (7; 50.0 %), followed by single (4; 28.6 %) and de facto marital status (3; 21.4 %). The participants had been institutionalized for an average of 4.5 ± 6.4 years. All participants completed the program, with no dropouts recorded.

### 3.2. Feasibility program

Furthermore, the Intrinsic Motivation Inventory (IMIp) and the System Usability Scale (SUS) were applied to the intervention participants, with the following results (table 1). The mean score for the application of the IMIp was 82.2 ± 9.9, indicating that participants experienced a high level of intrinsic motivation and engagement with the Nintendo Switch® games. Regarding the SUS instrument, participants had an average score of 52.9 ± 14.1, which qualitatively reflects below-average usability.

Regarding the subscales of the IMIp, the pleasure/interest subscale had a mean score of 16.4 ± 2.2, competence scored 20.4 ± 3.7, effort/importance scored 25.4 ± 2.4, and the pressure/tension subscale had a mean score of 20.0 ± 4.1, as shown in Table 2. These results suggest that participants found the activity moderately exciting and enjoyable in terms of pleasure/interest. In the competence subscale, participants felt relatively competent in performing the tasks within the games. Regarding the effort/importance subscale, participants invested a relatively high level of effort and considered the activity important. Lastly, in the pressure/tension subscale, participants reported moderate tension during the activity. However, this subscale had the highest standard deviation, indicating a wide range of responses—while some participants were more comfortable with the activity, others felt more pressure.

## 4. Discussion

In this study, the usability of the Nintendo Switch® for elderly individuals was evaluated, focusing on ease of use, understanding of the games, the user interface, and the engagement and adherence levels of the elderly participants in the program. The results indicate that the experience was positive overall, but also highlighted areas where participants felt more challenged or under pressure. During the sessions, older people expressed phrases of satisfaction with their participation and performance in the games, such as "This is very funny," "Today I'm playing better than last week," "Oh no, here comes the ball again," and "I don't want to let it fall." These findings align with other studies on elderly perceptions of gaming (Barg-Walkow et al., 2017; Freed et al., 2021). The Nintendo Switch® games used in this intervention were not explicitly designed for this age group, and this was reflected in their feedback. While commercially available games offer a cost-effective and quick way to implement more engaging rehabilitation interventions (Leal et al., 2023), they can present significant user challenges. It is important to note that these elderly participants had not previously been exposed to this type of game, which may have influenced their perception of usability and motivation to engage with them. Selecting the most suitable exergame for a specific age group or patient type remains challenging. More research is still needed to develop a better understanding of this.

In this study, the average SUS score was 52.9, indicating that the usability of the Nintendo Switch® for this population is below average. Several studies evaluate the usability of games and other technologies; however, there is still limited evidence regarding the Nintendo Switch®, as it is a relatively recent console. In the study by the authors (Zegarra-Ramos et al., 2024)' satisfaction with treatment was assessed through a questionnaire. Their objective was to promote healthy ageing

**Table 1**
Descriptive results from the IMIp and SUS evaluation.

| Variables | min | max | Mean ± SD |
|---|---|---|---|
| **IMIp** | 62 | 97 | 82.2 ± 9.9 |
| **SUS** | 33 | 73 | 52.9 ± 14.1 |

**Table 2**
Descriptive results for the subscales of IMIp.

| Variables | min | max | Mean ± SD |
|---|---|---|---|
| Pleasure/Interest | 12 | 19 | 16.4 ± 2.2 |
| Competence | 14 | 27 | 20.4 ± 3.7 |
| Effort/Importance | 21 | 29 | 25.4 ± 2.4 |
| Pressure/Tension | 14 | 24 | 20.0 ± 4.1 |

in individuals with cognitive impairment by using the Nintendo Switch® in combination with occupational therapy sessions, aiming to improve fine and gross motor skills, functionality, quality of life, and cognitive status. They concluded that all assessed parameters showed significant improvements. Additionally, the participants reported high satisfaction with using this technology (Zegarra-Ramos et al., 2024).

The average IMIp score of 82.2 indicates that participants had a high level of motivation for playing the game.

Playing exergames is recognized by several studies as a powerful catalyst for promoting regular physical exercise (Barg-Walkow et al., 2017; CS Fernandes et al., 2022). It serves as a valuable tool for rehabilitation in addressing specific physical and mental health issues (CS Fernandes et al., 2022; Zegarra-Ramos et al., 2024; CS Fernandes et al., 2022). Furthermore, by playing these games, even in elderly institutions, participants regularly engage with their peers, thereby promoting socialization (Freed et al., 2021). Loneliness is one of the most prevalent issues among elderly individuals residing in care homes, as some perceive a sense of unhappiness resulting from the gap between their desired and actual levels of social relationships (Zhang et al., 2020). This situation may also stem from a need for more interaction with family members, friends, and neighbours (Smith et al., 2023). A systematic review with meta-analysis revealed that "moderate loneliness" is common among the elderly living in care homes, affecting about 61 %. In comparison, "severe loneliness" impacts approximately 35 % of this population (Gardiner et al., 2020).

Playing exergames is widely recognized in the literature as an effective tool for promoting regular physical exercise, particularly among older populations, by combining physical activity with playful and motivational elements (Zeng et al., 2020; de Araujo et al., 2022). Recent studies show that exergames can significantly enhance physical activity levels, contributing to maintaining mobility, muscle strength, and flexibility in older adults (Lee et al., 2021). Moreover, these games have demonstrated mental health benefits, reducing symptoms of depression and anxiety, promoting overall well-being, and increasing quality of life (Oliveira et al., 2023).

In care settings, such as nursing homes, exergames also serve as a means of socialization, encouraging participant interaction during gameplay sessions, which can help mitigate feelings of loneliness (Kim et al., 2021). Loneliness is one of the most prevalent issues among older adults living in institutions, often associated with a discrepancy between desired and actual levels of social relationships (Cheng et al., 2020). A lack of regular interaction with family, friends, and neighbours can exacerbate this. A recent systematic review revealed that approximately 58 % of elderly residents in care homes experience "moderate loneliness, " while 32 % face "severe loneliness" (Li et al., 2021). Including exergames in physical and cognitive rehabilitation programs offers an innovative and effective approach to addressing these challenges and improving physical and mental health among older populations (Pereira et al., 2023).

Understanding how users perceive the usability and motivation for using exergames is essential for the successful continued use of this technology. Success depends on the health benefits gained from implementing these tools and the likelihood of their continued use in daily life (Money et al., 2019). Elderly individuals often have limited technology knowledge, so it is crucial to provide training that increases technical confidence and ensures safety (Medeiros et al., 2024). The results of the authors' systematic review (Medeiros et al., 2024), as in the present study, emphasize that the usability of exergames is satisfactory, making them a practical option for promoting regular physical activity.

Given the above, it is necessary to understand the obstacles elderly individuals face when interacting with exergames and to develop strategies to overcome them, such as providing training support materials. Additionally, improving system support by including in-game tutorials, simplifying instructions, and allowing users to handle navigation controls beforehand to enhance their " Joy-Con " skills could be beneficial. This approach can reduce frustration and complexity while maximizing the benefits of using these tools.

When developing future exergames for older people, it would be advantageous to incorporate co-design stages with the direct participation of this age group and conduct specific tests throughout the development process. This would ensure the games are intuitive, accessible, and tailored to their physical and cognitive needs.

Based on the evidence reviewed, it is clear that exergames have the potential to support elderly individuals in various activities by improving their physical and mental capacities, which can contribute to active and successful ageing. Despite the potential limitations some elderly users experienced with this tool, numerous studies highlight its growing role in rehabilitation (CS Fernandes et al., 2022; Freed et al., 2021; Zegarra-Ramos et al., 2024; CS Fernandes et al., 2022; Medeiros et al., 2024). When considering the integration of the Nintendo Switch® into rehabilitation programs, it is also essential to assess initial costs, ensure continuous training for professionals, and plan for regular maintenance of the equipment to ensure long-term sustainability and the effectiveness of interventions. Regarding engagement and adherence, there was complete adherence to the program, demonstrated by the participants' high motivation and consistent session attendance. This reinforces the effectiveness of incorporating exergames into regular activities and suggests a sustainable continuation of this technology among older people. However, it is necessary to first familiarize participants with the game type.

### 4.1. Limitations

As with all studies, some limitations must be addressed in this investigation. First, the sample size may limit the generalization of the results and may not represent the broader population. Second, usability and motivation were looked at just once after all 16 intervention sessions. This way may not show how participants' experiences changed over time. It also increases the chance of recency bias since the latest experiences might have affected participants' answers more than others. This limitation indicates that regular evaluations would have given a better view of usability and motivation during the intervention. Third, while efforts were made to standardize the intervention environment, certain environmental factors, such as participants' sensitivities to lighting or noise, could not be fully controlled. These variables may have influenced usability and motivation scores and should be considered in future studies.

Another limitation of this study is the need for game-specific analysis for usability and motivation scores. During the intervention, participants played different games (Bowling, Badminton, Tennis, and Volleyball), but the scores were only evaluated after the last session. This method does not make it possible to see which games were more or less engaging for elderly users. Future research should break down data by type of game to better understand preferences and difficulties related to each game.

Lastly, another limitation of this study is the need for a detailed qualitative analysis. Although participant feedback was noted informally, a formal method like interviews or thematic analysis was not used to examine their experiences thoroughly. Using a mixed-methods approach added more context to the quantitative results, giving a better understanding of why usability ratings were low despite high motivation scores.

## 5. Conclusions

This study evaluated the usability of the Nintendo Switch® by elderly individuals, considering ease of use, understanding of the game interface, as well as participants' motivation and adherence. The results indicate that, despite a high level of intrinsic motivation, the usability of the console was rated below average by the participants.

This study highlights the need for an inclusive, user-centred design approach, which could involve prior integration into the activity, mediated by adjusting strategies to account for older adults' cognitive and motor limitations. This would ensure that exergames can be effectively continually incorporated into rehabilitation programs, contributing to active and healthy ageing.

This study provided valuable information about using Nintendo Switch® exergames in rehab for older adults. Future research should try to fix the noted limitations. It is suggested that regular check-ups happen at specific points, like every 4 or 8 sessions, to observe how participants feel about usability and motivation over time. These check-ups could use shorter and more accessible tools, making it less demanding for participants and still gathering detailed information. This way, we would better understand how user experiences develop and the lasting effect of the program. Future studies systematically monitor and report environmental factors such as light, noise, and how many people are in a room to improve the robustness of findings. This would help understand how these factors affect participants, especially older adults.

Even with the study design's limitations, the results give helpful information about exergames as a rehab tool for older adults. The regular participation and strong engagement noted during the intervention show that participants were motivated to keep participating, even without regular feedback. Future studies should add more regular checks to understand better the long-term effects of exergames on user experience and motivation.

The conclusions of this study have significant practical and research implications, both for the adoption of gaming technologies and for future investigations into the gaming experience among older adults.

Future Directions: Future studies need to include a plan for long-term checks on usability and motivation to tackle the issues found in this research. Future studies should also expand these results by adding analyses specific to games. We also suggest using a mixed-methods strategy that includes qualitative data. Analyzing this data thematically could add to quantitative findings, offering better insight into how usability and motivation relate. This method would benefit studies with small samples focused on new interventions for older adults.

## CRediT authorship contribution statement

**Andreia Maria Novo Lima:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Maria Teresa Moreira:** Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Maria Salomé Ferreira:** Writing – original draft, Methodology, Funding acquisition, Conceptualization. **Vítor Parola:** Writing – review & editing, Supervision, Investigation, Data curation, Conceptualization. **Sandra Rodrigues:** Writing – original draft, Methodology, Investigation, Conceptualization. **Ana Cristina Corucho Barbeitos Pinto:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Telmo Lima Costa:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Carla Sílvia Fernandes:** Writing – review & editing, Supervision, Formal analysis, Data curation, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Data availability

Data will be made available on request.

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