# A pilot study on the feasibility and initial outcomes of a telerehabilitation system for balance and cognitive training in older adults

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**Aims.** This randomized controlled multicentric pilot study aimed to evaluate the feasibility, safety, and preliminary clinical efficacy of a home-based telerehabilitation system for improving balance and cognitive function in older adults.
**Methods.** The study was conducted in two four-week phases across multiple centres. In Phase A (n=18), participants were randomized into an experimental group (n=10) using a telerehabilitation balance training module (Stability Module) and a control group (n=8) receiving standard kinesiotherapy. In Phase B (n=11), a second cohort was randomized into an experimental group (n=5) receiving combined balance and cognitive training (Stability + ActiveCOG Modules) and a control group (n=6) receiving standard therapy. Outcomes were measured using the Berg Balance Scale (BBS) and Mini Mental State Examination (MMSE). Statistical analysis included paired t-tests, Fisher's exact test, Wilcoxon rank-sum test, and effect size estimation using Cohen's d.
**Results.** In Phase A, both the experimental and control groups showed significant within-group improvements in balance (BBS: $P$=0.004 and $P$=0.041, respectively), with no significant difference between groups. In Phase B, the intervention group demonstrated significant within-group improvements in both balance (BBS: $P$=0.009) and cognitive function (MMSE: $P$=0.034), while between-group differences did not reach statistical significance ($P \geq 0.05$). Effect sizes in Phase B suggested substantial clinical relevance (Cohen's d>1.0).
**Conclusion.** The study confirmed the feasibility and safety of the telerehabilitation system and highlighted its usability in home environments. While preliminary clinical improvements were observed, particularly with combined motor-cognitive training, the small sample size limits definitive conclusions. These findings support the feasibility of larger, longer-term trials to further evaluate clinical efficacy and scalability.

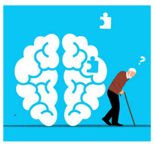
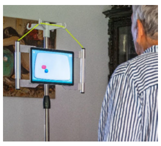
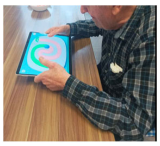
**TELEREHABILITATION FOR BALANCE AND COGNITIVE IMPROVEMENT IN OLDER ADULTS**

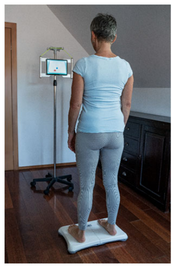
**This randomized controlled multicentric pilot trial demonstrates the feasibility and usability of a home-based telerehabilitation system for older adults.**

**The study was conducted in two four-week phases:**

**Phase A: Balance-only training using the Stability Module.**
**→ Assessed by the Berg Balance Scale (BBS).**

**Phase B: Combined balance and cognitive training using the Stability Module + ActiveCOG Module.**
**→ Assessed by the BBS and the Mini Mental State Examination (MMSE).**



**In the Phase B intervention group, significant within-group improvements were observed in: Balance (*BBS*, $P$=0.009), Cognitive function (*MMSE*, $P$=0.034).**

**The findings indicate that the system is feasible and safe for use in older adults, supporting its potential applicability in home-based care settings and suggesting that further research in larger, more diverse populations and over longer durations may help to validate and expand upon these preliminary results.**

**The study provides initial evidence supporting the feasibility and usability of a home-based telerehabilitation system in elderly populations. However, due to the small sample, further research is needed to confirm its clinical effectiveness.**

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**Key words:** telerehabilitation, older adults, balance training, cognitive training, dual-task intervention

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## INTRODUCTION

A common issue among older adults (65+) is the progressive decline in postural stability and executive functions, both of which significantly impact their independence and quality of life. Balance disorders are prevalent due to age-related changes in the sensory, musculoskeletal, and central nervous systems, often manifesting as dizziness, unsteadiness, and impaired gait[1]. These disorders are a leading cause of falls, which are the primary reason for injury-related hospitalization in older adults and are associated with increased morbidity, mortality, and long-term functional decline[2]. Furthermore, cognitive deficits, including mild cognitive impairment (MCI) and dementia, frequently coexist with balance problems, creating a vicious cycle that further increases fall risk[3].

Cognitive decline affects executive functions, such as attention, working memory, and dual-tasking ability, which are crucial for maintaining postural stability and adapting to changes in the environment[4,5]. Impaired dual-task performance, where cognitive and motor tasks are performed simultaneously, has been identified as a strong predictor of falls in older adults with cognitive impairment[6]. Recent evidence highlights that interventions combining physical and cognitive training, such as dual-task balance exercises, can improve both cognitive and physical outcomes, potentially reducing fall risk and enhancing quality of life[7].

Telerehabilitation (TR) has emerged as a significant alternative to traditional in-person rehabilitation, demonstrating positive impacts on patient outcomes and adherence. Research indicates that TR can effectively manage various conditions, improve quality of life, and enhance rehabilitation adherence compared to conventional methods. The following sections outline the key findings regarding TR's effectiveness and adherence rates. TR has been associated with 9% higher adherence to exercise programs compared to in-person physiotherapy, suggesting that the flexibility of TR may enhance patient commitment. Patient satisfaction with TR is comparable to traditional methods, indicating that patients are generally content with remote care[8].

As technology advances, assistive technologies are becoming integral to everyday practices, particularly for enhancing social, physical, and mental quality of life. Critical factors include acceptance of modern technologies across different age groups, technological literacy of users, and economic viability of solutions for society. Assistive technologies are increasingly used in physiotherapy, expanding the scope of telerehabilitation. Telerehabilitation involves utilizing modern technology to conduct rehabilitation remotely, often referred to as distance therapy. This approach is implemented in the patient's home environment[9,10].

The foundation of telerehabilitation lies in the transmission of data measured during therapy, such as kinesiotherapy (exercise units), and the connection with the therapist. Through telemonitoring in the patient's home environment, therapists or doctors gain access to objective data collected from sensors, providing information on factors like exercise duration and performance scores, enabling them to monitor the progress of therapy.

Each person undergoes an individual aging process, necessitating rehabilitation interventions tailored to the unique needs of the elderly individual. The selection of an appropriate rehabilitation intervention for geriatric patients involves consideration of various factors, with a crucial element being the senior's cooperation with the course of treatment. Unlike other age groups, there is no comprehensive guide to therapy specifically designed for old age and geriatric frailty[11,12].

Choosing the right rehabilitation intervention for geronts requires a thoughtful assessment of factors such as the senior's level of cooperation with the treatment plan. The overarching goal in geriatric rehabilitation is to maintain seniors' independence, self-sufficiency in daily activities, and to keep them motivated and mobile. This aligns with the general rule of thumb that guides geriatric care[10]. Most activities of daily living are an interaction of motor and cognitive functions, but training interventions for older adults are typically divided into physical and cognitive components. At the same time, combining motor and cognitive training can generate more synergistically beneficial changes[13]. The concept of brain training is based on the hypothesis that the brain's capacity for learning and plasticity persists throughout life[12].

The main objective of this pilot study was to assess the feasibility and safety of using telerehabilitation in older adults and to evaluate the preliminary clinical efficacy of the newly developed components of the telerehabilitation platform. This study aimed to provide information on user adherence, user satisfaction, and therapeutic outcomes for future large-scale research.

## MATERIALS AND METHOD

### Settings

This randomized controlled multicentric pilot study was conducted in the Czech Republic. Therapy sessions for Phase A took place between January 2021 and March 2023, while Phase B was conducted from January 2023 to April 2023. Baseline and outcome measurements were performed in-person within the participants' home environments. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of General University Hospital in Prague under reference number 1597/19 S-IV.

### Design

This randomized controlled multicentric pilot study aimed to evaluate the feasibility, safety and preliminary efficacy of a telerehabilitation intervention aimed at enhancing physical (especially balance-related) and cognitive functions in older adults. Both phases assessed not only clinical effect but also user satisfaction and adherence to the prescribed training regimen, while identifying potential barriers to long-term use. The primary objective was to gather evidence for the design and implementation of a larger study and to refine the intervention protocol.

The study was conducted in two phases, each with specific objectives: Phase A focused on testing the stability module to evaluate its impact on balance using standardized assessment tools. Phase B built on the findings of Phase A by incorporating newly developed cognitive training games (ActiveCOG) that included upper limb activation exercises and cognitive stimulation.

Randomization was performed using computer-generated numbers, with odd numbers assigned to the experimental group and even numbers to the control group.

The intervention protocol was refined during the study based on participant feedback and preliminary data. Phase B provided valuable insights into the feasibility of integrating cognitive and physical exercises into a home-based telerehabilitation system for participants with mild dementia, defined as having a Mini-Mental State Examination (MMSE) score of ≤ 24, which was one of the inclusion criteria for this phase. Standardized assessments of balance and cognitive function were conducted at baseline and post-intervention to measure clinical impact and validate the methodology for future studies.

**Participants**

Phase A

Phase A focused on a pilot group of seniors, comprising 18 participants. Inclusion criteria were:

- Age between 65 and 75 years
- Initial Berg Balance Scale (BBS) score below 45 points
- History of repeated falls
- Subjective instability during daily activities
- Ability to understand instructions and use technology.

The intervention group included 10 participants, while the control group comprised 8 participants.

Phase B

Phase B aimed to evaluate the integration of cognitive training into the telerehabilitation system with a total of 11 participants. Inclusion criteria were:

- Age over 65 years
- Ability to stand and walk independently or with light support
- At least slight instability when walking
- Mini-Mental State Exam (MMSE) score ≤ 24 points
- Ability to walk at least 20 meters with or without an assistive device.

The intervention group consisted of 5 seniors, and the control group included 6 seniors.

**Assessments**

The main outcome measures were:

- Berg Balance Scale (BBS) – to assess balance and fall risk
- Mini-Mental State Exam (MMSE) – to evaluate cognitive function

Both tests were administered at baseline and after the 4-week intervention period. Standardized testing protocols were followed to minimize bias, ensuring comparability between intervention and control groups. These standardized tests were used to evaluate the stability and cognitive function of the participants. All participants signed an informed consent form for the examination and subsequent therapy. The control and intervention groups were designed to be as homogeneous as possible in terms of age and initial health status.

**Training protocol**

Phase A

- **Experimental Group I:** Followed a specific exercise plan using the Stability Module, including exercises such as foot sole facilitation with a massage ball, semi-flexion of knee joints, and balance games (Balance Desk, Balance Pong, Balance Rings, and Balance Route). Sessions lasted 20–25 min, 2–4 times per week for 4 weeks.
- **Control Group II:** Engaged in classical kinesiotherapy exercises at home, focusing on stability improvement. Therapy duration and frequency were the same as in the experimental group.

Phase B

- **Experimental Group I:** Combined the Stability Module with cognitive training exercises. The plan included exercises focusing on both lower and upper limbs, followed by cognitive tasks. Sessions were held 3 times per week for 30 min over 4 weeks.
- **Control Group II:** Received classical kinesiotherapy without cognitive training, following the same therapy schedule.

**Telerehabilitation System**

The telerehabilitation system used in this study consists of a patient unit comprising a stabilometric platform and a tablet with a program featuring therapeutic exercises. The presented modules are implemented as functionalities of the control software, enabling the execution of an exercise plan. The telemedicine extension allows for remote configuration of the therapeutic exercise plan, remote recording of therapy progress and outcomes, a web-based cloud environment for managing remote therapy and evaluating health improvements.

The therapy principle is based on telemetry transmission, therapy with audiovisual feedback, and monitoring of the patient's physical activity. The system also integrates specialized tools for tracking the number of exercises performed, elements for assessing the quality of rehabilitation, and monitoring adherence to the therapeutic plan.

**Stability Module**

This module monitors physical activity parameters, specifically focusing on stability. Advanced functionalities support fall prevention and prevent subsequent complications. The BalanceDesk (see Fig. 1) module displays the patient's current center of gravity as a ball and, by transferring the weight, aims to get the ball to the target point and stay there for two seconds. Another module, BalanceRings (see Fig. 2), concentrates on balance and memory training. In this module, patients engage in a game where they must memorize the order of the displayed rings and guide the ball to the marked location in

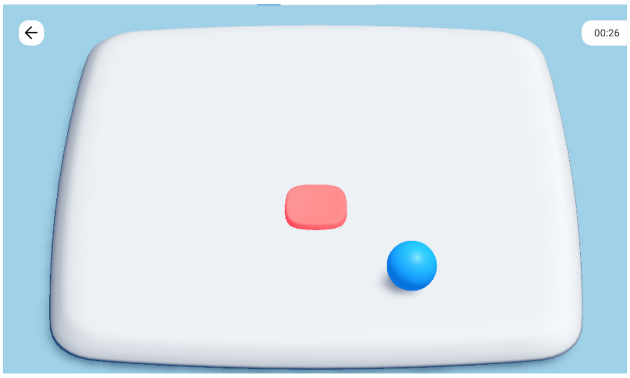


**Fig. 1.** BalanceDesk Game.

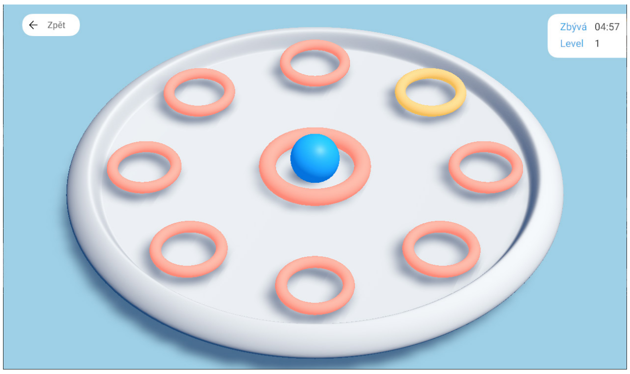


**Fig. 2.** BalanceRings Game.

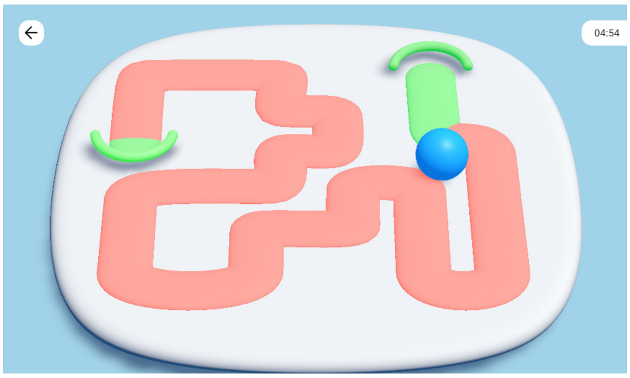


**Fig. 3.** BalanceRoute Game.

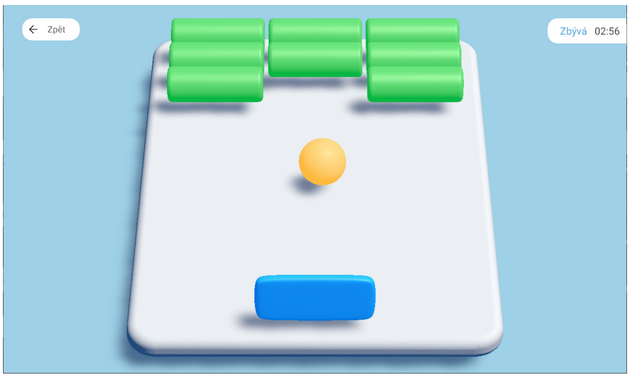


**Fig. 4.** BalancePong Game.

**Fig. 5.** Example of balance training using the stabilometric platform.

the correct sequence. The BalanceRoute (see Fig. 3) module features a game where patients attempt to navigate a marked route with a ball in the fastest time possible. The last module, Balance Pong (see Fig. 4), trains stability and reactions. Patients control the board by performing lateral shifts of their center of mass (see Fig. 5), with the task of keeping the ball in play for as long as possible without missing it.

### ActiveCOG module

The cognitive module is categorized into five sections (memory, speech, comprehension and attention, planning and decision-making, visual skills) to target and train each specific cognitive and executive function.

### Conventional kinesiotherapy

The exercise unit for the group of participants with conventional kinesiotherapy includes 18 exercises aimed at increasing stability, which are performed in several positions. In the first phase, when exercising lying on the back, the participant focuses on dorsal and plantar flexion in the ankle joints, circular movements in the ankle joints, flexion and extension of the lower limbs and abduction and adduction in the hip joints. This is followed by sitting exercises, where the facilitation of the sole of the foot using a massage ball is performed, exercises for the little foot, flexion and extension in the knee joints and increasing flexion in the hip joints. In the last phase, exercises in standing, the participant performs walking in place, weight transfer to the toes, heels, left and right lower limbs, standing on one leg, flexion and extension in the hip and knee joints, abduction in the hip joint and squatting. Exercises 7–16 are then performed on a balance pad, increasing the difficulty and effectiveness of the stability training. Each exercise is performed 10 times.

**Data analysis**

The statistical analyses were conducted using R Studio. The clinical effectiveness was assessed using Cohen's d to estimate the effect size. The interpretation of effect sizes was as follows: values below 0.2 indicated a small effect, those ranging from 0.5 to 0.8 indicated a medium effect, and values equal to or greater than 0.8 suggested a large effect. Fisher's exact test and Wilcoxon rank sum tests were used to analyse the baseline characteristics of the groups; the Wilcoxon rank sum test was applied when the data did not follow a normal distribution, while a two-sample t-test was used in cases where normality was confirmed. Paired t-tests were used to assess the efficacy of the therapies by comparing entry and exit values within the same participants.

Additionally, participant adherence and user satisfaction were assessed through informal feedback and subjective reports during the training protocol. Adherence was determined based on participation frequency and completion of prescribed exercises. User satisfaction was evaluated through qualitative feedback from participants, considering their experiences with the platform and the perceived usability and effectiveness of the therapy.

## RESULTS

The pilot study confirmed the feasibility and safety of using a telerehabilitation system for home-based rehabilitation in elderly participants. Technology usability was validated, and participant adherence to the training protocol was high, with the majority of participants completing the intervention as prescribed. In the experimental group using the telerehabilitation platform, exercise performance data were automatically recorded in a cloud-based system, allowing for objective monitoring of session frequency and completion. Therefore, adherence in this group can be considered high and reliably verified. User feedback was largely positive, particularly regarding the cognitive training modules, which were described as engaging and motivating.

The participants in the pilot study were randomly divided into two groups: an experimental group and a control group. Table 1 and Table 2 describe the baseline characteristics of these groups in Phase A and Phase B, respectively. The baseline characteristics for both phases (A and B) indicate that the groups are homogeneous in terms of age and gender, based on Fisher's exact test and Wilcoxon rank sums.

Table 1 presents the baseline characteristics for Phase A, comparing the experimental and control groups. Fisher's exact test and the Wilcoxon rank-sum test were used to assess homogeneity between the groups in terms of gender and age. The results show that there are no significant differences between the groups, as indicated by the *P* values for gender (>0.9) and age (0.9). Both groups have a similar distribution of gender, with the experimental group comprising 60% men and 40% women, while the control group has 62% men and 38% women. The median age for the experimental group is 68.5 years (IQR: 66.2, 71.0), and for the control group, it is 67.5 years (IQR: 66.5, 71.2), showing no significant difference between the groups. The mean age for the experimental group is 69.0 years (SD: 3.4) and for the control group is 68.6 years (SD: 4.6).

**Table 1.** Baseline Characteristics of Participants – Phase A.

| Characteristic | Experimental group, n=10 | Control group, n=8 | $P^1$ |
|---|---|---|---|
| Gender, n (%) | | | >0.9 |
| Man | 6 (60%) | 5 (62%) | |
| Woman | 4 (40%) | 3 (38%) | |
| Age | | | 0.9 |
| Median (IQR)[2] | 68.5 (66.2, 71.0) | 67.5 (66.5, 71.2) | |
| Mean (SD)[3] | 69.0 (3.4) | 68.6 (4.6) | |

[1]Fisher's exact test, Wilcoxon rank sum test; [2]IQR, Interquartile Range; [3]SD, Standard deviation.

Similarly, Table 2 describes the baseline characteristics for Phase B, comparing the experimental and control groups. Fisher's exact test and Wilcoxon rank-sum test were again applied, showing no significant differences between the groups. The gender distribution is similar, with 60% men and 40% women in the experimental group, and 50% men and 50% women in the control group. The median age for the experimental group is 88.0 years (IQR: 85.0, 88.0), while for the control group, it is 80.5 years (IQR: 73.8, 87.2). The mean age for the experimental group is 85.6 years (SD: 5.8), and for the control group, it is 80.7 years (SD: 8.4). Although there is a slight difference in age, the *P*-value for age (0.4) suggests no statistically significant difference between the groups.

**Table 2.** Baseline Characteristics of Participants – Phase B.

| Characteristic | Experimental group, n=5 | Control group, n=6 | $P^1$ |
|---|---|---|---|
| Gender, n (%) | | | >0.9 |
| Man | 3 (60%) | 3 (50%) | |
| Woman | 2 (40%) | 3 (50%) | |
| Age | | | 0.4 |
| Median (IQR)[2] | 88.0 (85.0, 88.0) | 80.5 (73.8, 87.2) | |
| Mean (SD)[3] | 85.6 (5.8) | 80.7 (8.4) | |

[1]Fisher's exact test, Wilcoxon rank sum test; [2]IQR, Interquartile Range; [3]SD, Standard deviation.

**BBS and MMSE assessment**

The outcome data includes the results from BBS and MMSE tests. Table 3 shows the results for monitored Phase A parameters, while Table 4 presents the Phase B endpoints.

Table 3 shows results of monitored phase A parameters. The individual treatment scores for Group I and Group II represent the average scores obtained in the initial and final therapy assessments using the BBS. In the initial testing, Group I scored 44 points, while Group II scored 43 points. In the final therapy testing, Group I achieved a mean score of 46 points, and Group II scored 45 points. **Statistical analysis revealed significant results for both tested groups, with *P* values of 0.004 for Group I and 0.041 for Group II.**

**Table 3.** Pre- and Post-Intervention BBS Scores – Phase A.

| Variable | Entry (SD) | Output (SD) | $P^1$ |
|---|---|---|---|
| Group I – Experimental group – Phase A | 44 (1.3) | 46 (1.4) | **0.004** |
| Group II – Control group – Phase A | 43 (1.2) | 45 (3.0) | **0.041** |

SD, Standard deviation; [1]Paired t-test.

The Table 4 presents the outcomes of the BBS and MMSE tests for each participant in the group. Paired t-tests were conducted to assess the efficacy of therapy, and the resulting *P*-values are displayed. The results indicate that therapy involving the telerehabilitation system and the additional modules of Stability and ActiveCOG is clinically effective (BBS $P$=0.009) and (MMSE $P$=0.034). The impact of the experimental intervention is comparable to standard therapy.

**Table 4.** Pre- and Post-Intervention BBS and MMSE Scores – Phase B.

| Variable | Entry (SD) | Output (SD) | $P^1$ |
|---|---|---|---|
| Group I BBS – Experimental group – Phase B | 47 (4.1) | 48 (3.9) | **0.009** |
| Group II BBS – Control group – Phase B | 48 (1.9) | 48 (1.2) | 0.175 |
| Group I of MMSE – Experimental group – Phase B | 23 (0.89) | 24 (1.1) | **0.034** |
| Group II MMSE – Control group – Phase B | 22 (0.82) | 22 (0.52) | 1 |

SD, Standard deviation; [1]Paired t-test.

**Increments of observed effects Phase A and Phase B**

Phase A

Table 5 presents the increments of observed effects in Phase A for both the experimental and control groups. The table compares the average increments in the Berg Balance Scale (BBS) scores between the two groups. The increment was calculated as the difference between each participant's post-intervention and pre-intervention BBS scores. The experimental group showed an average increment of 2.0 (SD=1.63), while the control group showed an average increment of 1.75 (SD=1.98). The P value (0.778) obtained from a two-tailed t-test indicates no statistically significant difference between the groups in terms of the change in BBS scores. The Cohen's d value is 0.139, which suggests a small effect size, further supporting the lack of significant difference between the groups. The confidence interval (CI) for the difference in the increments is −0.867 to 1.146, indicating that the true difference could be negative or positive, but it is not statistically significant.

With a *P* value of 0.778, no statistically significant difference was found between the two groups. **This suggests that both therapies are equally effective.** Regarding clinical efficacy, the Cohen's d value is 0.139, indicating a small clinical effect.

**Table 5.** Comparison of Pre–Post Increases in BBS Scores – Phase A.

| Variable | Average Increment (SD) | | $P^1$ | Cohen's d |
|---|---|---|---|---|
| | Experimental group | Control group | | |
| BBS – Phase A | 2.0 (1.63) | 1.75 (1.98) | 0.778 | 0.139 CI (−0.867–1.146) |

SD, Standard deviation; [1]Independent sample t-test.

Phase B

Table 6 shows the average increases in effects across the groups after exercise intervention. The clinical parameters assessed were the BBS and MMSE tests. With a significance level of $P$<0.05, no statistically significant difference was observed for either parameter, **indicating comparable effectiveness of therapies**. In terms of clinical effectiveness, **Cohen's d is 1.192 for BBS**, suggesting a substantial clinical effect. Similarly, for **MMSE, Cohen's d is 1.061**, indicating a significant clinical effect.

**Table 6.** Comparison of Pre–Post Increases in BBS and MMSE Scores – Phase B.

| Variable | Average Increment (SD) | | $P^1$ | Cohen's d |
|---|---|---|---|---|
| | Experimental group | Control group | | |
| BBS – Phase B | 1.8 (0.837) | 0.667 (1.03) | 0.075 | 1.192 CI (−0.293–2.678) |
| MMSE – Phase B | 1 (0.707) | 0 (1.10) | 0.103 | 1.061 CI (−0.402–2.523) |

SD, Standard deviation; [1]Independent sample t-test.

Phase A included 18 participants and focused on the feasibility and preliminary effectiveness of using a CE-marked telerehabilitation system for balance improvement, assessed with the Berg Balance Scale (BBS). Both the experimental group (using the telerehabilitation system) and the control group (receiving conventional therapy) showed significant improvements in their BBS scores, with p-values of 0.004 for the experimental group and 0.041 for the control group. Although the experimental group demonstrated slightly greater improvement, the difference was not statistically significant. These results suggest that telerehabilitation therapy is at least comparable to conventional therapy in improving balance.

Phase B involved 11 participants and expanded the focus to both balance and cognitive functions, using the BBS and the Mini Mental State Exam (MMSE) as outcome measures. The experimental group demonstrated significant improvements in both balance and cognitive scores, indicating the potential of the combined Stability and cognitive training modules to enhance physical and cognitive functions in elderly users. These findings provide preliminary evidence that integrating cognitive training with physical therapy may offer added value in telerehabilitation.

## DISCUSSION

The purpose of this pilot study was to assess the feasibility, safety, and initial effectiveness of the distance methodology and exercise modules designed to support physical activity and memory training in elderly individuals. The goal was to evaluate technology usability and identify the clinical potential of the newly developed therapeutic intervention in a controlled, small-scale setting. Through phase-based testing, preliminary findings suggest that the telerehabilitation system shows promise in being as effective as conventional therapy. The focus of this phase was to tailor the medical device for use within a specific, homogeneous group of seniors. The exercise plans tested in this pilot study were integrated with newly developed cognitive training modules, with the intention to explore their applicability across a broad age range. Interactive elements, including audiovisual feedback and the regularity of exercises, were incorporated to encourage active participation and motivate users in therapy.

This pilot study serves as an essential step in understanding the potential of the telerehabilitation system, helping to refine methodologies and providing insights for the design of a larger, full-scale study in the future. The system offers numerous advantages, including the creation of personalized therapeutic plans tailored to the individual needs of the participant. Another benefit is its ability to motivate users to achieve better results, as they can see whether they have improved compared to the previous therapy session. In most cases, when comparing the first and last therapy sessions, an improvement in scores was observed across individual exercises. However, the system also has certain disadvantages, such as the challenges of working with technology that users may not have encountered before. Many seniors face challenges in operating new technology, particularly in learning to control the balance platform. After some instruction and a trial period to familiarize themselves with the device, participants felt more confident. Initially, all seniors were apprehensive about potentially damaging the device, but after a week, competitiveness and a desire to improve in the exercises took over. The exercises with the telerehabilitation system were very enjoyable for the participants. Most of them noticed improvements, especially in their confidence while walking, after completing the therapy. Throughout the training protocol, we encountered some minor technical issues with connecting the platform to the tablet. Despite these challenges, participants' adherence to the exercise regimen remained high, and the feedback suggests that the system was not only effective but also engaging.

For telerehabilitation, we opted to use a telerehabilitation platform, deeming it suitable for the targeted participant group. Our decision aligns with findings from existing studies on balance disorders and the application of telerehabilitation. For instance, Novotna et al.[14] conducted a pilot study on balance training using visual biofeedback for individuals with multiple sclerosis experiencing balance disorders. Their results suggest that exercise with this system could be an effective therapy for improving balance in multiple sclerosis patients, showing a statistically significant improvement in the experimental group on the BBS ($P$=0.041). Although our BBS Phase B assessment yielded a $P$ value of 0.075, which is above the conventional threshold for statistical significance, factors such as the higher average age of our participants and the reduced frequency of practice sessions compared to the mentioned study may have influenced the results. Another relevant study is "Recent Considerations on Gaming Console Based Training for Multiple Sclerosis Rehabilitation", which explores the efficacy of exercise using the Nintendo Wii Balance Board. This study was selected for comparison due to the similar technical parameters of the stabilometric platform used in our pilot study. The participants were randomly assigned to two groups: the Wii group with 22 participants and the standard rehabilitation group with 20 participants. Both groups engaged in exercises five times a week for four weeks under the supervision of a physiotherapist. In the final therapy assessment, they repeated various examinations. The results in the Wii group demonstrated improvements in the BBS and Functional Independence Measure (FIM) (ref.[15]). In our study, comparing the initial and final examinations of Phase B in Group I (telerehabilitation exercise intervention), the BBS examination showed a $P$ value of 0.075, approaching statistical significance, while the clinical effect size was substantial (Cohen's d=1.192). These similarities further support the validity of our results and highlight the potential effectiveness of stabilometric platform-based rehabilitation in improving balance and functional independence.

The intervention duration of four weeks chosen for this study is in line with recommendations and findings from other studies, which have shown that even short-term interventions can lead to improvements in balance and cognitive functions in older adults. The study by Novotna et al.[14], utilized a similar four-week intervention length with a training plan focused on balance through the telerehabilitation platform. This study demonstrated a significant improvement in balance in patients with multiple sclerosis, confirming that a four-week program is sufficiently long to induce a clinically significant effect on postural control.

In our pilot study, both phases were conducted over a four-week period. In Phase A, the Stability module was tested, while in Phase B, both the Stability module and the ActiveCOG module were assessed. In Phase A, both the experimental and control groups showed improvements in balance scores measured by the Berg Balance Scale (BBS), with mean increases of 2.0 (SD=1.63) and 1.75 (SD=1.98), respectively. However, no statistically significant difference was found between the groups ($P$=0.778) and the effect size was small (Cohen's d=0.139), suggesting that both interventions were comparably effective.

As can be seen from the results of the BBS and MMSE tests for Phase B, see Table 4 for each participant in the experimental group, the results indicate that the telerehabilitation intervention combining the Stability and ActiveCOG modules had a statistically significant effect on both balance (BBS, $P$=0.009) and cognitive function (MMSE, $P$=0.034). While the overall comparison between the experimental and control groups in Phase B did not reach statistical significance ($P$≥0.05), the within-group improvement in the experimental group demonstrated substantial clinical relevance.

Furthermore, the clinical effect sizes observed in Phase B reinforce the potential impact of the combined motor-cognitive intervention. The effect sizes observed in Phase B were substantial, with Cohen's d=1.192 for BBS and 1.061 for MMSE. According to standard interpretations[16], an effect size above 0.8 is considered large, indicating a meaningful clinical impact. These values suggest that the telerehabilitation intervention influenced both balance and cognitive function, reinforcing its potential as an effective therapeutic approach. Although statistical significance was not reached for the between-group comparison, these findings suggest that integrating cognitive and balance training within telerehabilitation may offer significant benefits. Importantly, no deterioration was observed in any participant, which may reflect the stabilizing effect of the intervention – a key factor in preventing falls and promoting functional independence in older adults. These promising results warrant further investigation in larger, longer-term studies.

Our findings are consistent with previous research demonstrating the positive impact of cognitive training on balance and mobility in older adults. A systematic review by Khan et al.[17] found that motor-cognitive dual-task training can improve balance by facilitating attentional shifting between tasks, with attention theory cited as the most common explanatory mechanism. Similarly, Divandari et al.[18] identified a relationship between executive functions and postural balance. In our study, the intervention that included cognitive training led to improvements in both balance and cognitive function, particularly in Phase B. Although, unlike Barcelos et al.[19] we did not observe statistically significant improvements in cognitive function, significant gains were noted in BBS and MMSE scores. These findings support the conclusions of the systematic review by Pichierri et al.[20], suggesting that combining physical and cognitive training may have a synergistic effect. The use of telerehabilitation approaches, such as exergaming[21-23], appears to be a promising option for home-based rehabilitation, with added benefits in motivation and adherence[10]. Furthermore, telerehabilitation provides a flexible and accessible mode of care, allowing for individualized therapy in the home environment[24]. Adoption of such systems by older adults is feasible, provided they are tailored to users' needs and accompanied by adequate instruction[25].

**Learning points**

This pilot study highlights the potential of telerehabilitation as a feasible and effective method for supporting functional health in older adults. The integration of modern technologies enables therapy to be delivered in the home environment, with the added benefit of remote monitoring – especially valuable for individuals with limited access to in-person care. However, variability in participants' digital literacy and engagement may affect treatment adherence and outcomes, underlining the importance of individualized assessment. Evaluating each participant's ability to interact with and benefit from the system is essential for ensuring valid and objective conclusions. While the small sample size and short duration of the intervention limit the generalizability of the results, the study provides a valuable foundation for future research. Long-term studies involving larger cohorts are needed to validate these findings and assess the sustainability of therapeutic gains and continued use of telerehabilitation platforms.

**Limitations**

This pilot study has several limitations that should be acknowledged. First, the sample size was small and unequally distributed between phases. Different participants were involved in Phase A and Phase B, as each phase required distinct inclusion criteria. Many participants from Phase A would not have met the criteria for Phase B, which specifically focused on individuals with mild dementia and required an MMSE score below 24. While Phase A primarily assessed the effect of telerehabilitation on balance improvement, Phase B adjusted the inclusion parameters to better capture cognitive impairment and used more sensitive gait-related tests for evaluating stability.

Another important limitation lies in the comparison of two different interventions. While the control group performed classical kinesiotherapy, which typically involves exercises in lying, sitting, and standing positions, the telerehabilitation system is designed for use exclusively in a standing position. Although this discrepancy in body positions may represent a methodological limitation and could influence physical outcomes, it reflects the standardized nature of conventional rehabilitation practice.

The short duration of the intervention (4 weeks) further limits the ability to draw conclusions about long-term effectiveness. Moreover, the cognitive training module (ActiveCOG) was developed exclusively in the Czech language to suit the target population, which may affect its applicability in broader international settings.

## CONCLUSION

The study aimed to evaluate the effectiveness, usability and protocol safety of the telerehabilitation system in improving physical and cognitive functions in elderly participants.

Overall, it can be said that the use of telerehabilitation as part of healthcare presents a promising approach for improving both physical and cognitive health in seniors. This pilot study suggests that the four-week intervention with the telerehabilitation platform, which integrates exercises aimed at stability and cognitive activation, shows initial effectiveness. However, to assess the long-term effects and refine therapeutic plans, further research with a larger sample size and extended intervention duration is needed to validate these findings and optimize the approach for broader use.

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**Institutional review board statement**: The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of General University Hospital in Prague under reference number 1597/19 S-IV. Due to the pilot nature of this study, which primarily aimed to assess feasibility and gather preliminary data, formal registration was not pursued. The focus of this study was on evaluating the initial effectiveness and safety of the telerehabilitaton platform in a small, controlled group, with the goal of refining the intervention protocol for future, larger-scale trials. Moreover, the intervention program incorporated established therapeutic techniques alongside innovative elements designed to evaluate the potential integration of telerehabilitation into existing clinical practices.

**Informed consent statement**: Informed consent was obtained from all subjects involved in the pilot study.

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