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***Title page with author details**

Running title: Telerehabilitation of balance after stroke

Title: Effectiveness, usability, and cost-benefit of a virtual reality-based telerehabilitation program for balance recovery after stroke: a randomized controlled trial.

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Highlights

- Virtual reality-based training can be effectively combined with conventional programs
- Telerehabilitation and in-clinic administrations can promote similar motor improvement
- The usability and the motivation of both interventions can be similar
- Telerehabilitation interventions can involve savings that vary on each scenario

Abstract

Objective

First, to evaluate the clinical effectiveness of a virtual reality-based telerehabilitation program in the balance recovery of hemiparetic individuals post-stroke in comparison to an in-clinic program; second, to compare the subjective experiences; and finally, to contrast the costs.

Design

Single-blind randomized controlled trial.

Setting

Neurorehabilitation unit.

Participants

Chronic outpatients with stroke (N=30) with residual hemiparesis.

Interventions

Twenty 45-minute training sessions with the telerehabilitation system, administered three times a week, in the clinic or in home.

Main Outcome Measures

First, Berg Balance Scale for balance assessment. Balance and gait subscales of the Performance-Oriented Mobility Assessment, and the Brunel Balance Assessment were secondary outcomes. Clinical assessments were conducted at baseline, 8 weeks (post treatment), and 12 weeks (follow-up); Second, the System Usability Scale and the Intrinsic Motivation Inventory for subjective experiences; Finally, expenses in dollars for cost.

Results

Significant improvement in both groups from the initial to the final assessment in the Berg Balance Scale (p=0.001, η^2_p =0.68), in the balance (p=0.006, η^2_p =0.24) and gait subscales (p=0.001, η^2_p =0.57) of the Tinetti Performance-Oriented Mobility Assessment, and in the Brunel Balance Assessment (χ^2=15.0, p=0.002; χ^2=21.9, p=0.001). No significant differences between groups in any balance scale, nor in the feedback questionnaires. With regards to subjective experiences, both groups considered the VR system similarly usable and motivating. The in-clinic intervention resulted in more expenses than the telerehabilitation program (654.72 $ per person).

Conclusions

First, virtual reality-based telerehabilitation interventions can promote the reacquisition of locomotor skills associated with balance in a similar way that in-clinic interventions, both complemented with a conventional therapy program; second, the usability and the motivation of both interventions can be similar; and finally, the telerehabilitation interventions can involve savings that vary depending on each particular scenario.

Keywords

Telerehabilitation; virtual reality; virtual rehabilitation; balance; stroke; acquired brain injury.

List of abbreviations

ANOVA, Analysis of variance; BBA, Brunel balance assessment; BBS, Berg balance scale; IMI, Intrinsic motivation inventory; LCD, Liquid-crystal-display; PC, Personal computer; POMAb, Balance subscale of the performance-oriented mobility assessment; POMAg, Gait subscale of the performance-oriented mobility assessment; SUS, System usability scale; TV, Television; VE; Virtual environment; VR, Virtual reality.

Introduction

The stroke scenario defies worldwide social and health policies due to different reasons. First, stroke presents high and increasing incidence and prevalence rates.[1] Second, stroke survivors often present functional impairments that can decrease their personal autonomy and quality of life,[2] leading to a need of healthcare and rehabilitation. Third, the clinical heterogeneity that characterizes the pathology, with different symptoms and severity, exceeds the rigid boundaries of classical medical specialties. Finally, the rehabilitation process can be slow and last for years.[3] The classical six-month period of maximum recovery proposed in late 1990's[4,5] has been refuted by recent evidence-based research, showing the effectiveness of rehabilitation programs implemented even years after injury.[6-8] Modern knowledge about brain plasticity under physiological and pathological circumstances also supports this evidence.[9] These facts, among others, make the rehabilitation process after stroke a challenge for the economy of national institutes of health, insurance companies, and families.

Home-based rehabilitation programs try to derive part of the therapy from neurorehabilitation units to the home setting.[10] These programs offer great flexibility to tailor individual schedules, can partially release therapists from their time-constrained schedules, can reach remote areas where clinical facilities may not be present, and can save expenses (as those derived from round trips to the neurorehabilitation unit).[11] The latest advantages in technology provide therapists with new and effective tools not only to treat different impairments after stroke but also to adapt and monitor the therapy from a distance. This is the case of Virtual Reality (VR)-based interventions, which have been reported to provide clinical improvement[12,13] and cortical reorganization[14] through repetitive, adaptive, task-oriented, meaningful, and challenging exercises. While different telerehabilitation paradigms have been applied to stroke population[10], the

feasibility of VR-based telerehabilitation interventions remain a promise still vaguely studied.[15-18]

The objectives of the present study are threefold: 1) to evaluate the clinical effectiveness of a VR-based telerehabilitation program in the balance recovery of hemiparetic individuals post-stroke in comparison to an in-clinic program using the same VR system; 2) to compare the subjective experiences of the participants after undergoing the different interventions; and 3) to contrast the costs of both programs.

Methods

Participants

All the outpatients of the neurorehabilitation unit of a large metropolitan hospital and presented a residual hemiparesis after a stroke were eligible candidates to participate in the study. Eligibility criteria for the study were 1) age ≥ 40 and ≤ 75 years; 2) chronicity > six months; 3) Brunel Balance Assessment[19]: section 3, levels 7-12; 4) Mini-Mental State Examination[20] > 23; and 5) internet access in their homes. Exclusion criteria were 1) individuals with severe aphasia (Mississippi Aphasia Screening Test[21] cut-off < 45); 2) individuals with hemispatial neglect; and 4) individuals with ataxia or any other cerebellar symptom.

Subjects who met all inclusion criteria and accepted to participate in the study received detailed information. Written informed consent was obtained from all of them. The study was approved by the Institutional Review Board of the hospital. Subjects were randomly assigned to an in-clinic group (control) or to a home-based telerehabilitation group (experimental). The allocation sequence was concealed from an independent researcher. A sealed envelope identifying the group of each participant was given to the therapists to inform them of the allocation. Randomization was computer-

generated using a basic random number generator in a ratio of 1:1. A physical therapist (PTA), blind to the intervention, was responsible for assessing the participants and for supervising and adjusting their training. An independent physical therapist (PTB), who was not blind to the intervention, was responsible for explaining the training procedure and for providing technical support.

Instrumentation

The hardware system consisted of a TV, a standard computer, and a Kinect™ (Microsoft®, WA). A 42" LCD screen and a PC were used in the clinical setting. Participants belonging to the telerehabilitation group used their own TV and a laptop provided by us.

The VE used in the experiment represented the participants' feet and their movements in an empty scenario, which consisted of a checkered floor that facilitated the depth perception, with a central circle that represented the center of the VE. Different items rose from the floor around the circle. The objective of the exercise was to step on the rising items with the nearest foot while maintaining the other foot within the boundaries of the circle, and to recruit the extended foot afterwards (Figure 1). The level of difficulty of the task was defined by configuring the region of appearance, distance, size, lifetime, and number of simultaneous items. The therapists previously defined different levels of difficulty so that the system increased the level when the success rate of the participants was higher than 80%, and decreased the level when the rate was less than 20% (see Supplemental Materials).

Intervention

All the participants underwent twenty 45-minute training sessions with the system, administered three times a week (Monday, Wednesday, and Friday). Each session

consisted of six 6-minute repetitions with 90-second breaks among them. Participants belonging to the control group trained with the system in the clinic. Participants belonging to the experimental group trained in their homes. The difficulty of the training was initially adjusted by PTA in an exploratory session. During the intervention, the difficulty of the task was adjusted either by the therapist or automatically by the system. The evolution of all the participants was checked remotely once a week by PTA to detect possible issues and act accordingly. In addition, PTB had a brief interview with the participants of the experimental group each week to detect unwanted effects and to conduct troubleshooting. The time spent on these tasks was registered. The remaining days (Tuesday and Thursday), both groups received conventional physical therapy in the clinic. These sessions trained skills not related with balance to complement the motor training. After the intervention, all the participants returned to the conventional physical therapy program in the clinic.

The balance condition of all the participants was assessed before, after, and one month after the therapy with the Berg Balance Scale (BBS)[22], the balance (POMAb) and gait (POMAg) subscales of the Performance-Oriented Mobility Assessment[23], and the Brunel Balance Assessment (BBA)[19]. In addition, all the participants completed two questionnaires after the treatment about their experience with the system, the System Usability Scale (SUS)[24] and the Intrinsic Motivation Inventory (IMI)[25]. The SUS is a simple, ten-item scale that gives a global view of subjective assessments of usability (range: 0-100). The IMI is a multidimensional questionnaire structured in different subscales (range: 0-7), each of them composed of different questions. In our study, we assessed the participant's interest/enjoyment, perceived competence, pressure/tension, and value/usefulness. All the assessments were conducted in the clinic by PTA.

The costs of both programs were registered in terms of human resources (time spent on the assistance and guidance during the intervention, on the monitoring of the progress, and on the troubleshooting), round trips to the neurorehabilitation unit, and instrumentation (laptop, Kinect™, and internet access). During the in-clinic intervention, a physical therapist monitored the performance of the participant with the system while assisting other patients. As mentioned above, once a week PTA remotely monitored the progression of the participants. This process included the analysis of the outcomes and the adjustment of the difficulty. In addition, PTB had weekly interviews with the participants belonging to the experimental group. Both therapists recorded the time spent on the monitoring and on the problem resolution due to technical problems. The therapists never went to the participants' home. In case of unresolved technical issues, the participants brought the system to the clinic in the following visit.

Different primary outcomes were established depending on the objectives. First, with regards to the clinical effectiveness, the primary outcome was the BBS. Secondary outcomes were the POMAb, the POMAg, and the BBA. Second, with regards to the usability and motivation, the primary outcomes were the SUS and the IMI. Finally, with regards to the cost-benefit, the primary outcome was the cost in dollars.

Statistical analysis

The Kolmogorov-Smirnov test was used to assess whether the data showed a normal distribution. Demographical and clinical comparisons between the control and the experimental group were performed with independent sample t-tests and Chi-squared or Fisher exact tests, as appropriate. Repeated measures Analyses of Variance (ANOVA) with time as the within-subjects factor and treatment option (control versus experimental) as the between-subjects factor were performed for the BBS, the POMAb, and the POMAg. The main effects of time, treatment option and the time-treatment

option interaction effects were evaluated. ANOVA findings that violated the sphericity assumption were accommodated by Greenhouse and Geisser's conservative degrees of freedom adjustment. For each repeated-measures ANOVA, we present the partial eta squared (η^2_p) as a measure of effect size; values may range between 0 and 1, with higher values representing higher proportions of variance explained by the independent variable. Simple contrasts were conducted for each significant time main effect to determine the source of the significant difference. A Chi-square test was performed to compare the percentage of participants from the two groups who improved their level in the BBA after treatment. Comparisons of the subjective experiences reported by both groups were performed with independent sample t-tests.

The α level was set at 0.05 for all analyses (two-sided). All analyses were computed with SPSS for Mac, version 15 (SPSS Inc., IL).

Results

During the recruitment, a total pool of 115 outpatients were attending the neurorehabilitation unit. Of those, 23 subjects refused to participate in the study. A total of 37 subjects from the remaining sample (40.22%) met inclusion criteria. Six subjects were discarded due to high risk to be discharged of the neurorehabilitation program. The remaining sample, 31 participants, were randomized. The control group consisted of 16 participants, while the experimental group consisted of 15 participants. One participant of the control group was discharged of the program and dropped the study. Consequently, these data were not included in the study. Therefore, data from 30 participants, 15 in the control group and 15 in the experimental group, are included in this study (Figure 2).

The final sample consisted of 17 males and 13 females, with a mean age of 55.53±8.39 years, and a mean chronicity of 325.43±55.32 days. A total of 19

participants presented a hemorrhagic stroke and 11 participants presented an ischemic stroke (Table 1). No significant differences in demographical (gender, age) or clinical (etiology, hemiparetic side, chronicity) data at inclusion were detected between the groups. An independent t-test also revealed no significant differences in the clinical scales at the baseline ($p>0.05$).

Clinical effectiveness

A significant time effect was detected in both groups in the BBS ($p=0.001$, $\eta^2_p=0.68$), in the POMAb ($p=0.006$, $\eta^2_p=0.24$), and POMAg subscales ($p=0.001$, $\eta^2_p=0.57$), and in the BBA ($\chi^2=15.0$, $p=0.002$; $\chi^2=21.9$, $p=0.001$) (Table 2).

With respect to these variables throughout the therapy, post-hoc analysis showed significant improvement in both groups in all the scales from the initial to the final assessment. However, no significant improvement was detected from the final to the follow-up assessment in any of them. No significant group-by-time interaction was detected in any scale (Table 2, Table 3).

Usability and motivation

No significant differences were found between the two groups when comparing the scores in the SUS. The mean scores in both groups were high (87.50±5.40 in the experimental group and 85.40±4.70 in the control group), with individual scores ranging from 77 to 95. Similarly, no significant differences in the motivation of both groups were detected by the IMI. The scores in this scale were high (>4.9) for all the subscales in both groups with the exception of the pressure/tension subscale (Table 4).

Cost-benefit

With regards to the human resources, the VR-based balance recovery intervention in the clinic after the intervention required 8.34±0.36 h of a physical therapist, while the

home-based program required 1.63±0.78 h (Table 5). The in-clinic intervention also required twenty round trips to the clinic in a specialized vehicle. The home-based program required an estimated expenditure of 800 $ to acquire the hardware needed for the VR system.

To estimate the overall expenses of both interventions and to draw a specific case from the general, our own scenario was considered. Some assumptions were made to estimate the cost of each item. First, the mean base salary for physical therapists including the contributions to Social Security was 3605.25 $ for 22 business days with a 7.5 h schedule. Consequently, the cost of one hour of physical therapy was 21.85 $. Second, the patient transport services were private. The stipulated cost with established schedule was 32.70 $ for one-way trip. Finally, the cost of the instrumentation was representative of Spain.

The overall expenses of the balance intervention for one participant belonging to the in-clinic program were 1490.23 $, while the overall expenses for one participant belonging to the home-based group were 835.61 $. Therefore, the difference between both interventions was 654.72 $.

Discussion

Clinical effectiveness

The results in the primary outcome showed that all the participants, independent of group, improved during the intervention. No difference was found in the evolution of both groups, as reported by the BBS. Secondary outcomes confirmed this result.

The improvement observed in both groups, over all, from the initial to the final assessment, should be highlighted. An improvement of 3 to 4 points in the BBS scores between both assessments supports the clinical effectiveness of the VR-based

intervention, which proves that intensive, repetitive, adaptive, and task-oriented training can promote clinical benefits even long time after the injury. Remarkably, the detected changes are even higher than the minimum detectable change for chronic stroke population, established by some authors as being 2.5 points.[26] Previous results reported after interventions with the system also supports these findings.[27-29]

Results in the secondary outcomes supported these results. First, significant improvement was detected in the POMAb from the initial to the final assessment, even though the detected changes were not as remarkable as in the BBS. The sensitivity of the POMAb in detecting changes in the condition of our sample could have prevented greater effects. Second, four participants belonging to the control group and three participants belonging to the experimental group increased their balance condition in, at least, one level, according to the scores in the BBA. The increase from one level to the next one is, indeed, the minimum detectable change of this scale.[19] The detection of further improvement was not possible due to a ceiling effect. In the baseline, 22 participants, 11 belonging to each group, were already in the top level defined by the scale. Finally, even though gait was not specifically trained by the experimental exercise, an improvement in the general balance condition promoted by the training of the stepping strategy, weight shifting, and the dynamic postural adaptation (involving the upper extremities, trunk, pelvis, hip, knees, and ankles), together with the conventional physical therapy intervention, could have led to an improvement in gait, as reflected by the POMAg.

It is important to highlight that the intervention protocol described in this study combined a conventional physical therapy program with a VR-based intervention, and that both interventions were complementary.

Usability and motivation

The scores in the SUS and the IMI were high and no significant differences were found between groups, which suggests that all the participants considered the VR-based intervention usable and motivating, independently of the intervention.

The mean scores in the SUS were above the suggested cut-off of 70, proposed to define the VR system as acceptable in terms of usability, thus reflecting that the participants considered the system as being easy to use, easy to learn, and robust. In terms of motivation, the results of the IMI showed that most of the participants found the system enjoyable and defined it as a useful system to improve their deficits. Interestingly, even though the scores of the perceived competence in the IMI were high, they had the lowest values of the questionnaire. Enjoyment, conversely, was rated with the highest values. The continuous adaptation of the difficulty level could have led to a challenging task in each session, that even difficult, could have motivated the participants to improve in the task while being aware of their limits.

Cost-benefit

Time spent by the physical therapists in the control group was remarkably higher. The difference was expected to increase, considering the time spent on the troubleshooting to decrease along time. Beyond human resources, the most influential factor was the travel expenses (1308.11 $), which represented the 87.77 % of the total cost of the in-clinic intervention. This suggests that, under certain conditions, VR-based telerehabilitation programs can save costs, mainly derived from transportation services.

Limitations

First, the sample size, which consisted of 30 participants, is a small sample even though it is similar or even greater than other studies.[18,30] Second, the scales used may not reflect all the repercussions of the conventional and experimental training in the

participants' static and dynamic balance condition. In addition, more objective measures, such as posturographic data could have reflected more changes between groups.[31] Third, the characteristics of the sample are inherently linked to the specialized neurorehabilitation service where the study took place, which could restrict the generalization of the results. Fourth, there was no group that did not undergo the VR-based intervention. Even though improvements in balance could be attributable to other causes different from the experimental intervention, previous studies showed that the inclusion of VR-based training in conventional physical therapy programs promoted greater improvements than the conventional program itself [29]. Finally, with regards to the cost estimation, it is important to highlight that 1) the cost of the instrumentation of the in-clinic intervention was not considered. A representative cost involving the total cost of the instrumentation divided by the number of participants who used the system could have been also used; 2) the cost of the instrumentation was considered as if it was amortized only in the intervention. This value could have been divided by the number of months that the system was supposed to be used, thus decreasing the costs of the home-based intervention; and 3) these costs only represent our particular case. Extrapolation of the results should be particularized for each case.

Conclusions

Our results suggest that 1) VR-based telerehabilitation interventions can promote the reacquisition of locomotor skills associated with balance in a similar way that VR-based in-clinic interventions, both complemented with a conventional therapy program; 2) the usability and the motivation of both interventions can be similar; and 3) the telerehabilitation intervention can involve savings that vary depending on each particular scenario. Consequently, VR-based telerehabilitation interventions complemented with conventional therapy programs could be considered in those cases

when cost savings are mandatory and/or when the transport to the clinic is difficult (and in those subjects who satisfy the medical requirements).

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Figure Legends

Figure 1. Participants training with the system

The figure shows two participants training with the virtual reality-based exercise. a) Participant belonging to the control (in-clinic) group. b) Participant belonging to the experimental (home-based) group.

Figure 2. CONSORT flow diagram

The CONSORT flow diagram keeps track of the number of participants enrolled, allocated to each study group, followed up, and analyzed.

Figure

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a) b)

Figure

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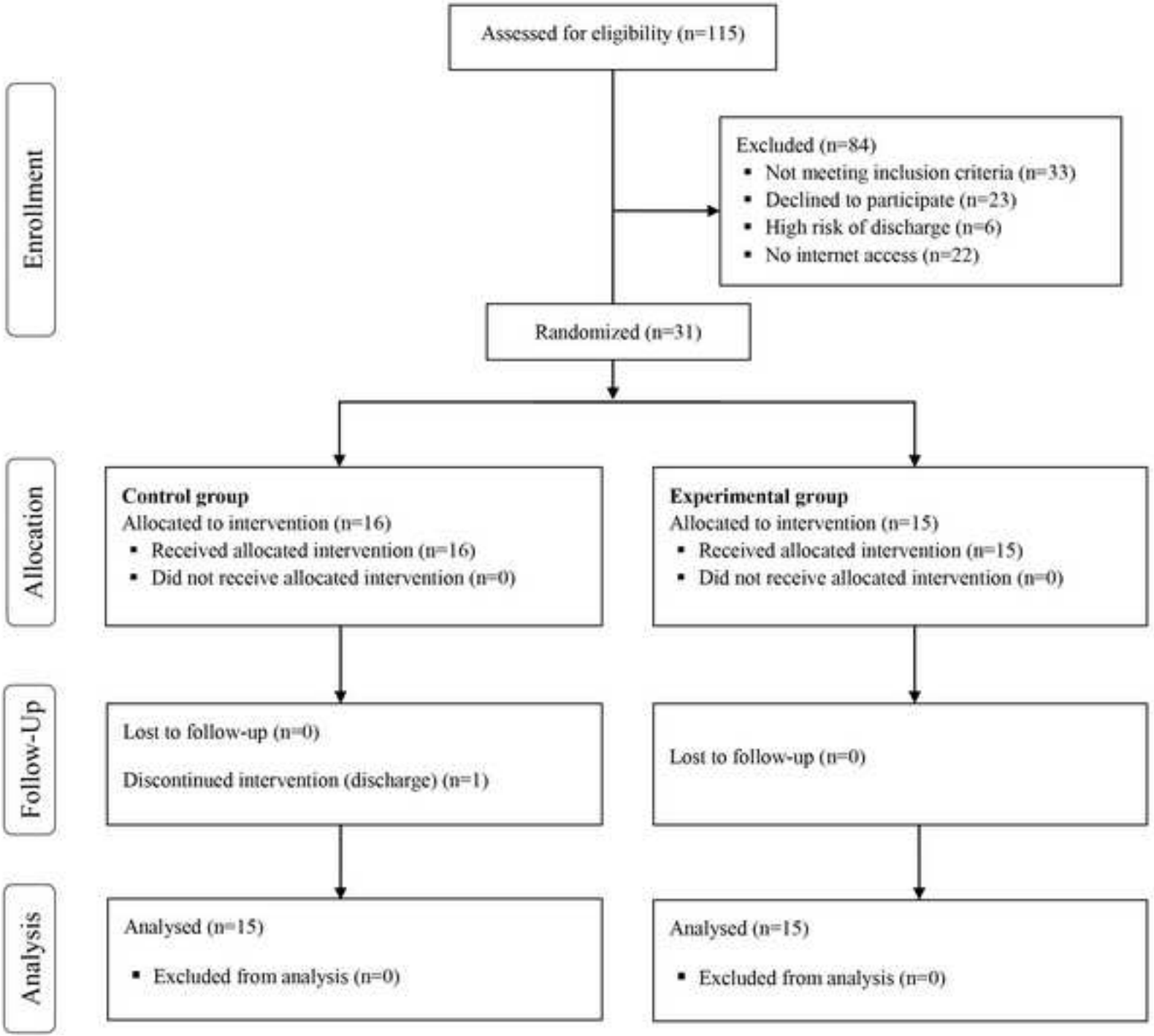

Table 1. Characteristics of the participants.

Characteristic	Control group (n=15)	Experimental group (n=15)	Significance
Gender (n, %)			NS (p=0.269)
Male	7 (46.7%)	10 (66.7%)	
Female	8 (53.3%)	5 (33.3%)	
Age (years)	55.60±7.29	55.47±9.63	NS (p=0.966)
Etiology (n, %)			NS (p=0.705)
Ischemic stroke	10 (66.7%)	9 (60.0%)	
Hemorrhagic stroke	5 (33.3%)	6 (40.0%)	
Hemiparesis (n, %)			NS (p=1.000)
Left	9 (60.0%)	9 (60.0%)	
Right	6 (40.0%)	6 (40.0%)	
Chronicity (days)	316.73±49.81	334.13±60.79	NS (p=0.398)

Age and chronicity are defined in terms of mean and standard deviation. Etiology and gender are expressed as a percentage of the total number of participants. NS: non-significant.

Table 2. Clinical data.

	Initial assessment (week 0)	Final assessment (week 8)	Follow-up assessment (week 12)	Significance (p, effect size)
BBS				T**(p=0.001, η^2_p =0.68)
Control	48.80±5.01	51.07±5.09	51.27±5.12	
Experimental	47.53±3.85	51.20±2.11	51.53±2.07	
POMAb				T*(p=0.006, η^2_p =0.24)
Control	15.07±1.10	15.33±0.72	15.53±0.74	
Experimental	14.53±1.68	15.40±0.82	15.47±0.74	
POMAg				T**(p=0.001, η^2_p =0.57)
Control	10.40±1.45	10.80±1.37	10.93±1.22	
Experimental	10.00±0.93	10.93±0.79	11.00±0.84	
BBA (n)				
Control				T_1**(χ^2=15.0, p=0.002)
Level=7	0	0	0	
Level=8	1	0	0	
Level=9	1	0	0	

Level=10	0	1	1	
Level=11	2	1	1	
Level=12	11	13	13	
Experimental				T_1**(χ^2=21.9, p=0.001)
Level=7	1	0	0	
Level=8	0	0	0	
Level=9	0	0	0	
Level=10	2	0	0	
Level=11	1	3	2	
Level=12	11	12	13	

Only significant results are shown. Results in the BBS, the POMAb, and the POMAg are given in terms of mean and standard deviation. T: time effect. T_1: time effect from the initial to the final assessment. *p<0.05, **p<0.01.

Table 3. Within-group change scores.

	Initial to final assessment		Final to follow-up assessment	
	Change	95% CI	Change	95% CI
BBS				
Control	2.26±1.79	1.27; 3.25	0.67±0.17	-0.17; 0.57
Experimental	3.66±2.38	2.35; 4.98	0.33±0.61	-0.01; 0.67
POMAb				
Control	0.26±0.45	0.01; 0.52	0.20±0.41	-0.03; 0.43
Experimental	0.86±1.50	0.01; 1.70	0.67±0.59	-0.26; 0.40
POMAg				
Control	0.40±0.60	0.50; 0.75	0.13±0.30	-0.06; 0.32
Experimental	0.93±0.59	0.61; 1.26	0.07±0.45	-0.19; 0.32

Change is expressed in terms of mean and standard deviation. CI is expressed as the minimum and maximum values on the interval. CI: confidence interval.

Table 4. Usability and motivation reports.

	Control	Experimental	Significance
SUS	85.40±4.70	87.50±5.40	NS (p=0.961)
IMI			
Interest/Enjoyment	6.02±0.28	6.16±0.27	NS (p=0.671)
Perceived competence	4.90±0.33	5.02±0.34	NS (p=0.902)
Pressure/Tension	1.09±0.41	1.28±0.36	NS (p=0.909)
Value/Usefulness	5.99±0.64	6.12±0.56	NS (p=0.460)

Results are defined in terms of mean and standard deviation. NS: non-significant.

Table 5. Cost of both interventions estimated for one patient.

	Control	Experimental
Human resources (h)		
Physical therapy[a]	7.50±0.00	-
Monitoring[b]	0.84±0.36	0.77±0.41
Troubleshooting[b]	-	0.86±0.67
Round trips (n)		
Control	20	-
Instrumentation[b] ($)		
Laptop	-	600 $
Kinect™		150 $
Internet access	-	50 $

Time is expressed in terms of mean and standard deviation. [a]Results are estimated as the number of sessions by the half of the session time. [b]Prices are estimated according the Spanish framework. Similar results can be obtained in other countries. The cost of the instrumentation for the clinic was not taken into account.

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Appendix. Difficulty of the exercises

The level of difficulty of the task was defined by configuring the region of appearance, distance, size, lifetime, and number of simultaneous items. Before the intervention, the therapists defined nine levels of difficulty. The system automatically increased the level of difficulty when the success rate of the participants was higher than 80%, and decreased the level when the rate was less than 20%. In addition, the therapists defined particularized levels for those participants who succeeded in the highest level.

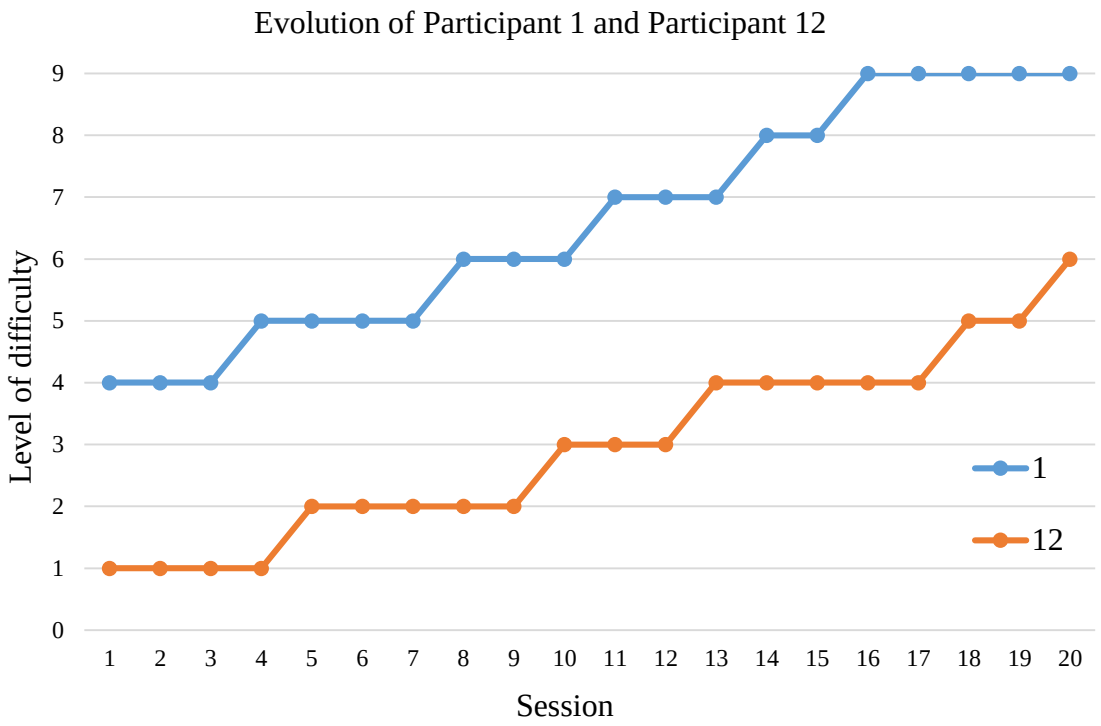
The difficulty of the training was initially adjusted by PTA in an exploratory session. During the intervention, the difficulty of the task was adjusted either by the therapist or automatically by the system.

Level	Number of simultaneous items (n)	Distance to item (cm)		Item lifetime (s)		Item size (cm)	
		min	max	min	max	min	max
1	1	30	30	5	10	15	20
2	1	40	40	10	10	15	20
3	1	50	50	10	10	15	20
4	1	50	50	10	10	10	10
5	1	50	50	3	3	10	10
6	2	50	50	10	10	15	20
7	2	50	50	10	10	10	10
8	2	50	50	3	3	10	10
9	3	60	60	3	3	10	10

The table shows the specifications of nine different levels of difficulty. The features considered to configure the levels were the number, distance, size, and lifetime of the items. Distance was defined from the center of the virtual environment to the item. Lifetime defined the time since the item appeared to it disappeared.

The frequency of the stepping task depended on the delay time between items, which was set to two seconds, but also on the time spent by the participants to step on the item, which triggered the countdown. Even though it varied on each participant, level of difficulty, and session, participants performed an average of 15 steps in a minute.

Participants showed similar progression (See table below). The next figure depicts the evolution of two participants. Participant 1, who belonged to the experimental group, suffered an ischemic stroke 287 days before the intervention. The subject scored 47 in the BBS in the initial assessment and increased the score to 52 after the intervention. Participant 12, who belonged to the control group, suffered a haemorrhagic stroke 331 days before the intervention. The subject scored 41 in the BBS in the initial assessment and 49 after the intervention.


Evolution of Participant 1 and Participant 12
Level of difficulty
0
1
2
3
4
5
6
7
8
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Session
1
12

	Session																			
Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4	4	4	5	5	5	5	6	6	6	7	7	7	8	8	9	9	9	9	9
2	2	2	2	3	3	3	3	3	3	4	4	4	4	5	5	5	6	6	6	7
3	1	1	1	1	2	2	2	2	3	3	3	3	3	4	4	4	5	5	5	6
4	5	5	5	5	5	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7
5	5	5	5	6	6	6	6	7	7	7	8	8	8	8	8	9	9	9	*	*
6	1	1	2	2	2	2	3	3	3	4	4	4	4	4	5	5	5	5	5	5
7	1	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	6
8	6	6	6	6	7	7	7	7	7	7	8	8	8	8	9	9	9	9	*	*
9	4	4	5	5	5	5	6	6	6	7	7	8	8	8	8	8	9	9	9	9
10	5	5	5	5	6	6	6	7	7	7	7	7	7	8	8	8	8	9	9	9
11	5	5	5	6	6	6	6	6	7	6	6	6	6	6	7	7	7	7	8	8
12	1	1	1	1	2	2	2	2	2	3	3	3	4	4	4	4	4	5	5	6
13	6	6	6	6	6	6	7	7	7	7	7	8	8	8	8	8	9	9	9	*
14	2	2	2	2	2	3	3	3	3	3	3	4	4	4	4	4	5	5	5	5
15	3	3	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	5	6	6
16	4	5	5	5	5	6	6	6	7	7	7	7	8	8	8	8	8	8	8	8
17	4	4	4	4	5	5	5	5	5	6	6	6	6	6	7	7	7	7	8	9
18	2	2	2	2	2	2	3	4	4	4	4	5	5	5	5	5	6	6	6	6
19	5	5	5	6	6	6	6	6	7	7	7	8	8	8	9	9	9	*	*	*
20	4	4	4	5	5	5	5	5	6	6	6	6	6	7	7	7	8	8	8	8
21	1	2	2	2	3	3	3	3	3	3	3	4	4	4	4	5	5	5	5	6
22	5	5	5	5	5	6	6	6	6	7	7	7	7	7	8	8	9	9	9	9
23	2	2	2	2	3	3	3	3	3	4	4	4	4	4	4	5	5	5	5	5
24	3	4	4	5	5	5	5	6	6	6	6	7	7	7	7	7	7	7	8	8
25	1	1	2	2	2	2	2	2	3	3	3	3	3	4	4	4	4	5	5	5

26	5	5	6	6	6	6	7	7	7	7	8	8	9	9	9	9	*	*	*	*
27	1	2	2	2	2	3	3	3	3	3	3	4	4	4	4	5	5	5	5	5
28	3	3	3	4	4	4	4	5	5	5	5	5	5	6	6	6	7	7	7	7
29	5	5	5	5	5	6	6	6	6	7	7	7	8	8	8	9	9	9	10	10
30	3	4	4	4	5	5	5	5	6	6	6	6	7	7	7	8	8	8	8	8

The table shows the evolution of the 30 participants in the level of difficulty. *: level of difficulty particularized to the participant.