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ORIGINAL ARTICLE

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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Abstract

Objectives: First, to evaluate the clinical effectiveness of a virtual reality (VR)—based telerehabilitation program in the balance recovery of individuals with hemiparesis after stroke in comparison with an in-clinic program; second, to compare the subjective experiences; and third, to contrast the costs of both programs.

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, conducted 3 times a week, in the clinic or in the home.

Main Outcome Measures: First, Berg Balance Scale for balance assessment. The Performance-Oriented Mobility Assessment balance and gait subscales, and the Brunel Balance Assessment were secondary outcome measures. Clinical assessments were conducted at baseline, 8 weeks (posttreatment), and 12 weeks (follow-up). Second, the System Usability Scale and the Intrinsic Motivation Inventory for subjective experiences. Third, cost (in dollars).

Results: Significant improvement in both groups (in-clinic group [control] and a home-based telerehabilitation group) from the initial to the final assessment in the Berg Balance Scale ($\eta_p^2 = .68$; $P = .001$), in the balance ($\eta_p^2 = .24$; $P = .006$) and gait ($\eta_p^2 = .57$, $P = .001$) subscales of the Tinetti Performance-Oriented Mobility Assessment, and in the Brunel Balance Assessment (control: $\chi^2 = 15.0$; $P = .002$; experimental: $\chi^2 = 21.9$; $P = .001$). No significant differences were found between the groups in any balance scale or in the feedback questionnaires. With regard to subjective experiences, both groups considered the VR system similarly usable and motivating. The in-clinic intervention resulted in more expenses than did the telerehabilitation intervention ($654.72 per person).

Conclusions: First, VR-based telerehabilitation interventions can promote the reacquisition of locomotor skills associated with balance in the same way as do in-clinic interventions, both complemented with a conventional therapy program; second, the usability of and motivation to use the 2 interventions can be similar; and third, telerehabilitation interventions can involve savings that vary depending on each scenario.

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The stroke scenario defies worldwide social and health policies because of different reasons. First, the incidence and prevalence of stroke are increasing.[1] Second, stroke survivors often have functional impairments that can decrease their personal autonomy and quality of life,[2] leading to a need for health care and rehabilitation. Third, the clinical heterogeneity that characterizes the pathology, with different symptoms and severity, exceeds the rigid boundaries of classical medical specialties. Fourth, the rehabilitation process can be slow and last for years.[3] The classical 6-month period of maximum recovery proposed in late 1990s[4,5] has been refuted by recent evidence-based research showing the effectiveness of

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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 the National Institutes of Health, insurance companies, and families.

Home-based rehabilitation programs try to transfer part of the therapy from neurorehabilitation units to the home setting.[10] These programs can be tailored to patients' 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 (such as those incurred from round-trips to the neurorehabilitation unit).[11] The latest advantages in technology provide therapists with new and effective tools not only to treat various 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. Although several telerehabilitation paradigms have been applied to the stroke population,[10] the feasibility of VR-based telerehabilitation interventions remains a promise still vaguely studied.[15-18]

The objectives of the present study were 3-fold: (1) to evaluate the clinical effectiveness of a VR-based telerehabilitation program in the balance recovery of individuals with hemiparesis after stroke in comparison with an in-clinic program using the same VR system; (2) to compare the subjective experiences of the participants after undergoing 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 presenting with residual hemiparesis after stroke were eligible to participate in the study. Inclusion criteria for the study were (1) age $\geq$40 and $\leq$75 years; (2) chronicity $>$6 months; (3) Brunel Balance Assessment (BBA)[19]: section 3, levels 7 to 12; (4) Mini-Mental State Examination score[20] $>$23; and (5) Internet access in their homes. Exclusion criteria were as follows: (1) individuals with severe aphasia (Mississippi Aphasia Screening Test[21] cutoff score $<$45); (2) individuals with hemispatial neglect; and (3) individuals with ataxia or any other cerebellar symptom.

Individuals who met all inclusion criteria and agreed 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 at NISA Hospitals, Spain. Participants 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 treating 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 (physical therapist A) blinded to the intervention was responsible for assessing the participants and for supervising and adjusting their training. An independent physical therapist (physical therapist B) who was not blinded to the intervention was responsible for explaining the training procedure and for providing technical support.

List of abbreviations:

ANOVA	**analysis of variance**
BBA	**Brunel Balance Assessment**
BBS	**Berg Balance Scale**
IMI	**Intrinsic Motivation Inventory**
POMA-B	**Performance-Oriented Mobility Assessment balance subscale**
POMA-G	**Performance-Oriented Mobility Assessment gait subscale**
SUS	**System Usability Scale**
VR	**virtual reality**

Instrumentation

The hardware system consisted of a television, a conventional computer, and a Microsoft Kinect (a motion-sensing input device).[a] A 42-in liquid-crystal display screen and a personal computer were used in the clinical setting. Participants belonging to the telerehabilitation group used their own television and a laptop provided by us.

The virtual environment used in the experiment represented the participants' feet and their movements in an empty scenario, which consisted of a checkered floor that facilitated the perception of depth, with a central circle that represented the center of the virtual environment. Various items were placed on the floor around the circle. The objective of the exercise was to step on these items with the nearest foot while maintaining the other foot within the boundaries of the circle and to bring the extended foot lose to the body afterward (fig 1). The level of difficulty of the task was defined by configuring the location of appearance, distance, size, lifetime (defined as time since the item appeared to the time it disappeared), and number of simultaneous items. The therapists previously defined levels of difficulty so that the system increased the level when the success rate of the participants was $>$80% and decreased the level when the success rate was $<$20% (supplemental appendix 1, available online only at http://www.archives-pmr.org/).

Intervention

All the participants underwent twenty 45-minute training sessions with the telerehabilitation system, conducted 3 times a week (Monday, Wednesday, and Friday). Each session consisted of six 6-minute repetitions with 90-second breaks between 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 progress of all the participants was checked remotely once a week by PTA to detect possible issues and respond accordingly. In addition, PTB had a brief interview with participants of the experimental group each week to detect possible technical problems and to troubleshoot. The time spent on these tasks was registered. On the remaining days (Tuesday and Thursday), both groups received conventional physical therapy in the clinic. These sessions trained participants in skills not related to balance to complement motor training. After the intervention, all the participants returned to the conventional physical therapy program in the clinic.

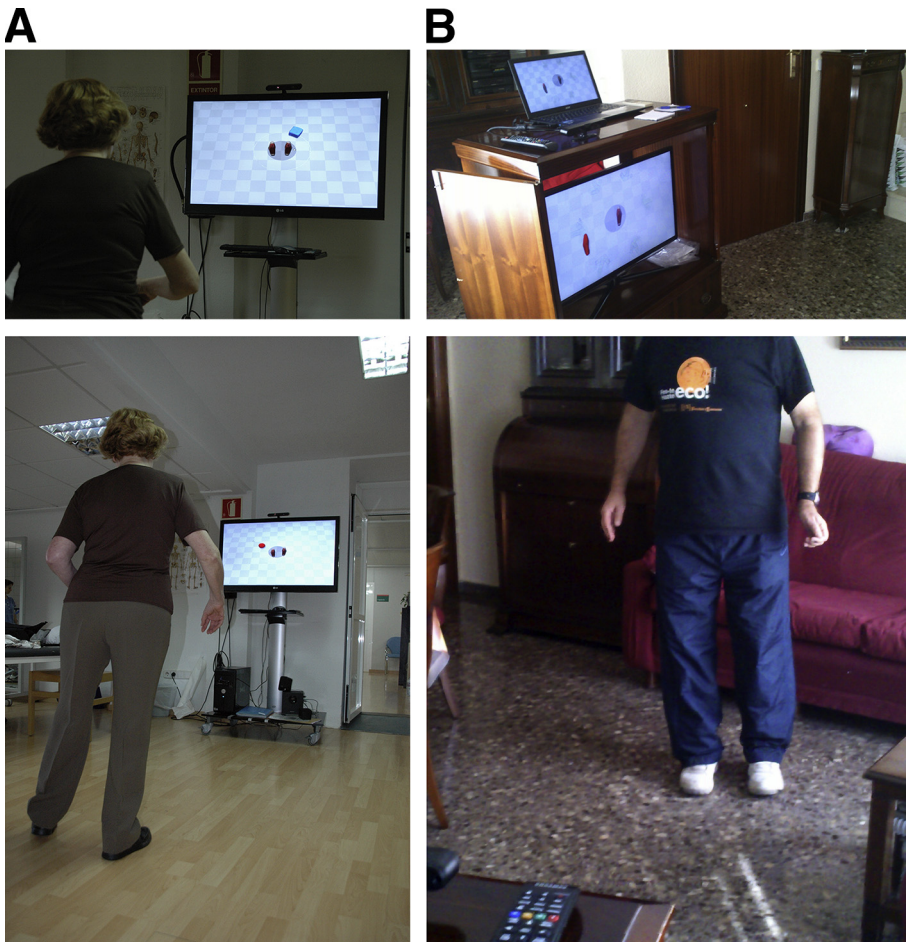

Fig 1 Two participants training with the virtual reality—based exercise: (A) participant belonging to the control (in-clinic) group; (B) participant belonging to the experimental (home-based) group.

The balance condition of all the participants was assessed before, after, and 1 month after the therapy with the Berg Balance Scale (BBS),[22] the Performance-Oriented Mobility Assessment balance subscale (POMA-B), the Performance-Oriented Mobility Assessment gait subscale (POMA-G),[23] and the BBA.[19] In addition, after the treatment all the participants completed 2 questionnaires about their experience with the system: the System Usability Scale (SUS)[24] and the Intrinsic Motivation Inventory (IMI).[25] The SUS is a simple 10-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 participants' 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 assistance and guidance during the intervention, monitoring of progress, and 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, PTA remotely monitored the progress of the participants once a week. This process included analysis of outcome measures and adjustment of 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 resolution of the problems due to technical issues. The therapists never went to the participants' home. In the case of unresolved technical issues, the participants brought the system to the clinic in the following visit.

Different primary outcome measures were established depending on the objectives. First, with regard to clinical effectiveness, the primary outcome measure was the BBS. Secondary outcome measures were the POMA-B, the POMA-G, and the BBA. Second, with regard to usability and motivation, the primary outcome measures were the SUS and the IMI. Third, with regard to cost-benefit, the primary outcome measure was the cost in dollars.

Statistical analysis

The Kolmogorov-Smirnov test was used to assess whether the data showed a normal distribution. Demographic and clinical comparisons between the control group and the experimental group were performed with independent sample *t* tests and chi-square or Fisher exact tests, as appropriate. Repeated-measures analyses of variance (ANOVAs) with time as the within-subjects factor and treatment option (control vs experimental) as the between-subjects factor were performed for the BBS, the

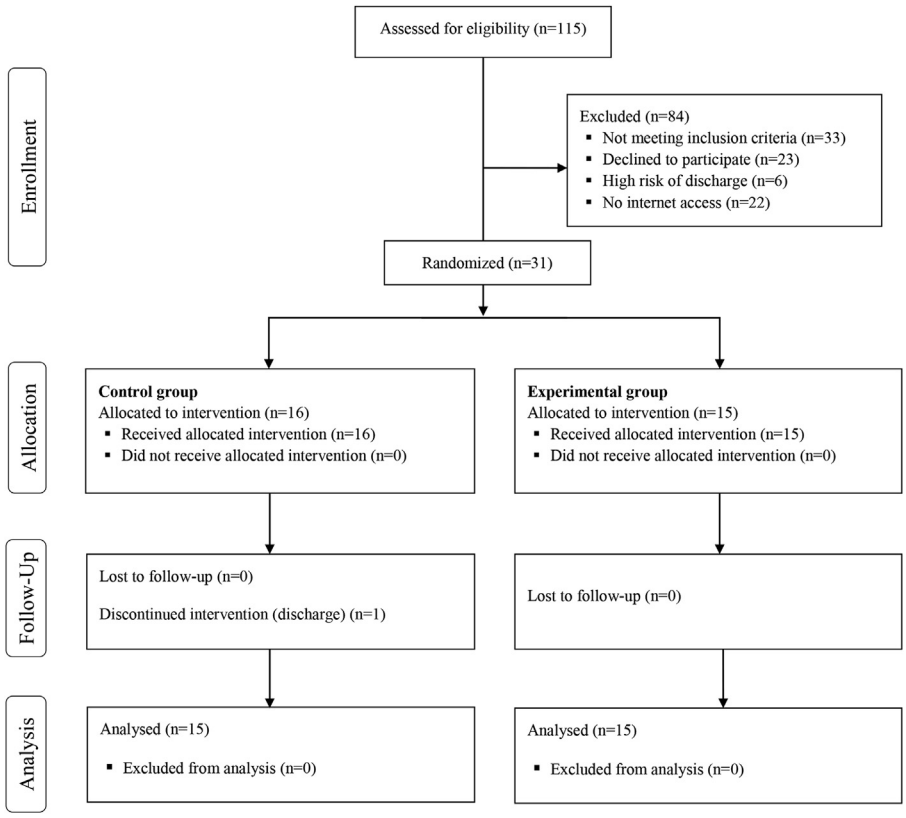

Fig 2 CONSORT flow diagram. It keeps track of the number of participants enrolled, allocated to each study group, followed up, and analyzed.

POMA-B, and the POMA-G. The main effects of time, treatment option, and the time-by-treatment option interaction 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 η_p^2 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 main effect of time to determine the source of the significant difference. A chi-square test was performed to compare the percentage of participants from the 2 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 alpha level was set at .05 for all analyses (2-sided). All analyses were computed with SPSS for Mac, version 15.[b]

Results

During the recruitment process, a total of 115 outpatients were attending the neurorehabilitation unit. Of those, 23 participants refused to participate in the study. A total of 37 (40.22%) participants from the remaining sample met the inclusion criteria. Six

Table 1 Characteristics of the participants

Characteristic	Control Group (n=15)	Experimental Group (n=15)	P*
Sex			P=.269
Male	7 (46.7)	10 (66.7)	
Female	8 (53.3)	5 (33.3)	
Age (y)	55.60±7.29	55.47±9.63	P=.966
Etiology			P=.705
Ischemic stroke	10 (66.7)	9 (60.0)	
Hemorrhagic stroke	5 (33.3)	6 (40.0)	
Hemiparesis			P=1.000
Left	9 (60.0)	9 (60.0)	
Right	6 (40.0)	6 (40.0)	
Chronicity (d)	316.73±49.81	334.13±60.79	P=.398

NOTE. Values are expressed as n (%) or mean SD.
* Not significant.

Table 2 Clinical data

Variable	Initial Assessment (Week 0)	Final Assessment (Week 8)	Follow-Up Assessment (Week 12)	Time Effect (Effect Size)	*P*
BBS				T* (η_p^2=.68)	*P*=.001
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		
POMA-B				T† (η_p^2=.24)	*P*=.006
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		
POMA-G				T* (η_p^2=.57)	*P*=.001
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					
Control				T_1* (χ^2=15.0)	*P*=.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*=.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		

NOTE. Only significant results are shown. Results in the BBS, the POMA-B, and the POMA-G are expressed as mean ± SD and in the BBA as numbers.
Abbreviations: T, time effect; T_1, time effect from the initial to the final assessment.
* *P*<.01.
† *P*<.05.

participants were excluded because of their high probability of being discharged from the neurorehabilitation unit. The remaining sample (31 participants) was randomized. The control group consisted of 16 participants, whereas the experimental group consisted of 15 participants. One participant of the control group was discharged from the program and thus dropped from the study. Consequently, the data for this participant were not included in the study. Therefore, data from 30 participants, 15 in the control group and 15 in the experimental group, were included in this study (fig 2).

The final sample consisted of 17 men and 13 women, 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 with hemorrhagic stroke and 11 participants presented with ischemic stroke (table 1). No significant differences were found between the groups in demographic (sex and age) or clinical (etiology, hemiparetic side, and chronicity) data at inclusion. An independent *t* test also revealed no significant differences in the clinical scales at baseline (*P*>.05).

Table 3 Within-group change scores

	Initial to Final Assessment		Final to Follow-Up Assessment	
Variable	Change	95% CI	Change	95% CI
BBS				
Control	2.26±1.79	1.27 to 3.25	0.67±0.17	−0.17 to 0.57
Experimental	3.66±2.38	2.35 to 4.98	0.33±0.61	−0.01 to 0.67
POMA-B				
Control	0.26±0.45	0.01 to 0.52	0.20±0.41	−0.03 to 0.43
Experimental	0.86±1.50	0.01 to 1.70	0.67±0.59	−0.26 to 0.40
POMA-G				
Control	0.40±0.60	0.50 to 0.75	0.13±0.30	−0.06 to 0.32
Experimental	0.93±0.59	0.61 to 1.26	0.07±0.45	−0.19 to 0.32

NOTE. Change is expressed as mean ± SD. CI is expressed as the minimum and maximum values of the interval.
Abbreviation: CI, confidence interval.

Table 4 Usability and motivation reports

Variable	Control	Experimental	P*
SUS	85.40±4.70	87.50±5.40	$P=.961$
IMI			
Interest/enjoyment	6.02±0.28	6.16±0.27	$P=.671$
Perceived competence	4.90±0.33	5.02±0.34	$P=.902$
Pressure/tension	1.09±0.41	1.28±0.36	$P=.909$
Value/usefulness	5.99±0.64	6.12±0.56	$P=.460$

NOTE. Results are expressed as mean ± SD.
* Not significant.

Clinical effectiveness

A significant time effect was detected in both groups in the BBS ($\eta_p^2=.68$; $P=.001$), the POMA-B ($\eta_p^2=.24$; $P=.006$), the POMA-G ($\eta_p^2=.57$; $P=.001$), and the BBA (control: $\chi^2=15.0$; $P=.002$; experimental: $\chi^2=21.9$; $P=.001$) (table 2).

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

Usability and motivation

No significant differences were found between the 2 groups when comparing the scores on 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 reflected by the IMI. The scores on 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 regard to human resources, the VR-based balance recovery intervention in the clinic after the intervention required 8.34±0.36 physical therapist hours, whereas the home-based program required 1.63±0.78 hours (table 5). The in-clinic intervention also required 20 round-trips to the clinic in a specialized vehicle. The home-based program required an estimated expense of $800 to acquire the hardware needed for the VR system.

Table 5 Cost of both interventions estimated for 1 patient

Variable	Control	Experimental
Human resources (h)		
Physical therapy*	7.50±0.00	NA
Monitoring†	0.84±0.36	0.77±0.41
Troubleshooting†	NA	0.86±0.67
Round-trips, n		
Control	20	NA
Instrumentation,† $		
Laptop	NA	600
Kinect		150
Internet access	NA	50

NOTE. Time is expressed as mean ± SD, and other variables as indicated.
Abbreviation: NA, not applicable.
* Results are estimated as the number of sessions by the half of the session time.
† Prices are estimated according to the Spanish framework. Similar results can be obtained in other countries. The cost of the instrumentation for the clinic was not taken into account.

To estimate the overall expenses of both interventions and to draw a specific case from the general, we considered our own scenario. Some assumptions were made to estimate the cost of each item. First, the mean base salary for physical therapists, including contributions to the Social Security fund, was $3605.25 for 22 business days with a 7.5-hour schedule. Consequently, the cost of 1 hour of physical therapy was $21.85. Second, the patient transport services were private. The stipulated cost with an established schedule was $32.70 for 1-way trip. Finally, the cost of the instrumentation reflects these costs in Spain.

The overall expenses of the balance intervention for 1 participant belonging to the in-clinic program were $1490.23, whereas the overall expenses for 1 participant belonging to the home-based program were $835.61. Therefore, the difference between the 2 interventions was $654.72.

Discussion

Clinical effectiveness

The results in the primary outcome measure suggested that all the participants, independent of the group, improved during the intervention. No difference was found in the progress of the 2 groups, as reflected by the BBS. Secondary outcome measures confirmed this result.

The overall improvement observed in both groups from the initial to the final assessment should be highlighted. An improvement of 3 to 4 points in the scores on the BBS 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 a long time after the injury. Remarkably, the detected changes are even higher than the minimum detectable change for the chronic stroke population, established by some authors as being 2.5 points.[26] Previous results reported after interventions with the system also support these findings.[27-29]

Results in the secondary outcome measures supported these results. First, a significant improvement was detected from the initial to the final assessment in the POMA-B, even though the detected changes were not as remarkable as in the BBS. The sensitivity of the POMA-B in detecting changes in the condition of our sample could have prevented significant effects. Second, 4 participants belonging to the control group and 3 participants belonging to the experimental group improved their balance condition in at least 1 level according to the scores on the BBA. The increase from one level to the next one is, indeed, the minimum detectable change in this scale.[19] The detection of further improvement was not possible because of a ceiling effect. At baseline, 22 participants, 11 belonging to each group, were already in the top level defined by the scale. Third, even though gait was not specifically trained or practiced by the experimental exercise, an improvement in the general balance condition promoted by the stepping exercise, weight shifting, and 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 POMA-G.

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

Usability and motivation

The scores on 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, independent of the intervention.

The mean scores on the SUS were above the suggested cutoff 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 suggested that most 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 on the questionnaire. In contrast, enjoyment was rated with the highest values. The continuous adaptation of the difficulty level could have led to a challenging task in each session that, though difficult, could have motivated the participants to improve in the task.

Cost-benefit

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

Study limitations

First, the sample size of 30 participants is small, even though it is similar to or even greater than that in 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 unit where the study was conducted, 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 causes different from those of the experimental intervention, previous studies showed that the inclusion of VR-based training in conventional physical therapy programs promoted greater improvements than did the conventional program itself.[29] Fifth, with regard to cost estimation, it is important to highlight the following: (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 also been 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 represent only 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 similarly to VR-based in-clinic interventions, both complemented with a conventional therapy program; (2) the usability of and motivation to use the 2 interventions can be similar; and (3) the telerehabilitation intervention can involve savings that vary depending on each scenario. Consequently, VR-based telerehabilitation interventions complementing conventional therapy programs could be considered in those cases when cost savings are mandatory, when the transport to the clinic is difficult, or both (and in those participants who satisfy the medical requirements).

Suppliers

a. Microsoft, WA.
b. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.

Keywords

Cost comparison; Postural balance; Rehabilitation; Stroke; Virtual reality therapy

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Supplemental Appendix 1 Difficulty of the Task

The level of difficulty of the task was defined by configuring the location of appearance, distance, size, lifetime, and number of simultaneous items. Before the intervention, the therapists defined 9 levels of difficulty. The system automatically increased the level of difficulty when the success rate of the participants was >80% and decreased it when the rate was <20%. In addition, the therapists defined particularized levels for those participants who succeeded at the highest level.

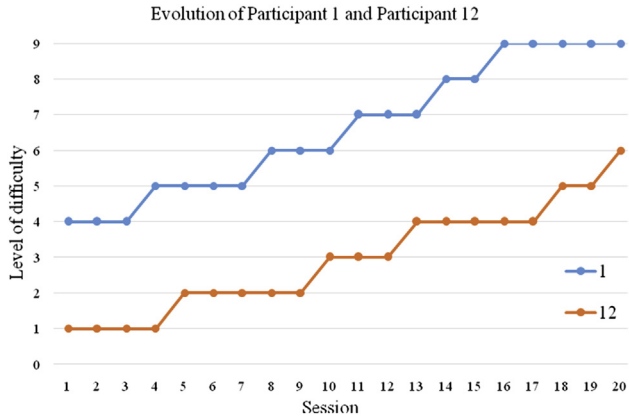
The difficulty of the training was initially adjusted by PTA in an exploratory session. During the intervention, the difficulty of the task was adjusted either by the therapist or automatically by the system.

		Distance to Item (cm)		Item Lifetime (s)		Item Size (cm)	
Level	No. of Simultaneous Items (n)	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 9 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 the time it disappeared.

The frequency of the stepping task depended not only on the delay time between items, which was set at 2 seconds, but also on the time spent by the participants to step on the item, which triggered the countdown. Even though it varied for each participant, level of difficulty, and session, participants performed an average of 15 steps in a minute.

Participants showed a similar progress (see table below). The figure given below depicts the evolution of 2 participants. Participant 1, who belonged to the experimental group, suffered an ischemic stroke 287 days before the intervention. The participant scored 47 on the Berg Balance Scale in the initial assessment, which increased to 52 after the intervention. Participant 12, who belonged to the control group, suffered a hemorrhagic stroke 331 days before the intervention. The participant scored 41 on the Berg Balance Scale in the initial assessment and 49 after the intervention.



	Session																			
Participant	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. The asterisk indicates the level of difficulty particularized to the participant.