



Effects of virtual reality on social participation after stroke: a systematic review

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ABSTRACT

Background: The cerebrovascular accident (CVA), or stroke, is characterized as a vascular injury occurring in the nervous tissue, in which there is interruption in the blood flow with consequent loss of the local supply of nutrients and oxygen, leading to tissue death. According to data from the Unified Health System and other studies, the CVA represents the greatest cause of death and permanent disability in Brazil. **Objectives:** The objective of this study was to perform a systematic review of the literature, searching for evidence of the effects of the use of the rehabilitation based on virtual reality to help recover the social participation of hemiparetic subjects after stroke. **Methods:** Searches were conducted on Medline, CINAHL, Web of Science, LILACS and PEDro databases, without restriction regarding the language and publication year of the study. The articles were evaluated by title, abstract and full text and, finally, selected in relation to the eligibility by two independent authors. The methodological quality of the included experimental studies was evaluated according to the PEDro scale. **Results:** Among the 11 articles included in the present review, only 4 demonstrated significant effects of virtual reality training on social participation/quality of life of hemiparetic subjects, when compared to the control group. **Conclusion:** The studies analyzed show that although there seems to be benefits of using virtual reality in global aspects of hemiparetic patient recovery, such as in motor function, the results are still not consistent regarding the social participation.

Keywords: Stroke; Virtual Reality; Social Participation.

INTRODUCTION

The cerebrovascular accident (CVA), or stroke, is characterized as a vascular injury occurring in the nervous tissue, in which there is interruption in the blood flow with consequent loss of the local supply of nutrients and oxygen, leading to tissue death⁽¹⁾. All age groups may be affected and the consequences of the event in general depend on the area affected and the degree of severity of the injury⁽²⁾. Usually the sequelae present itself in the hemisphere opposite to the hemisphere reached, preserving most of the functions on the ipsilateral side to the lesion⁽²⁾. According to data from the Unified Health System and other studies, the CVA represents the greatest cause of death and permanent disability in Brazil^(2,3).

Among the sequelae present in the survivors, there is usually muscle weakness, motor control impairment, sensory deficit, balance deficit, spasticity, asymmetry in the discharge of weight in the lower limbs and proprioceptive deficits⁽⁴⁾. Because of that, these subjects present difficulties in ambulation, limitations in the execution of activities of daily living and, consequently, remain restricted to their home, without involvement with the community, with restrictions on social participation⁽⁵⁾.

Maintaining social participation is important because it favors patients' motivation and adherence to treatments, preventing psychological dysfunctions such as depression and dementia, and

promoting a sense of self-efficacy, which are extremely relevant factors in the quality of life of patients^(6,7). Given this, it is necessary to seek interventions that are effective in helping the functional recovery and social participation of these patients, promoting their reintegration into the community. One of the resources recently explored is virtual reality, a tool that has proved to be efficient in the rehabilitation of hemiparetic patients⁽⁵⁾.

Virtual reality is defined as an multimedia and immersive environment, in which computers can simulate the physical presence of real or imaginary locations, as well as recreate sensory experiences⁽⁴⁾. It is considered an interactive and motivational resource that allows the therapist to modulate and manipulate the intensity and feedback of the proposed activities in an individualized way, according to the needs of the patient⁽³⁾. Some studies have shown that the use of the adequate platform allows training the skills necessary to the individual in his daily life, making the use of virtual reality promote cortical reorganization and improved coordination and balance. You et al., in one of the first trials on the subject, investigated the effects of the use of the therapy based on virtual reality in the motor recovery of patients with chronic stroke. In a sample of 10 patients, the authors performed qualitative and quantitative gait analyzes, as well as the

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Financial source: The authors declare that there was no financial source.

Submission date 05 January 2018; Acceptance date 03 July 2018; Publication date 15 October 2018





verification of magnetic resonance imaging before and after the intervention. The authors demonstrated that after four weeks of intervention the gait-related tests showed significant changes in score, and magnetic resonance imaging indicated suggestive signs of cortical reorganization in the supplemental motor area in the experimental group⁽⁵⁾.

Although the results of randomized clinical trials appear promising, the systematic review is the gold standard study to answer the scientific questions, because it summarizes all available literature on the subject using clear criteria of inclusion and exclusion of works to avoid biases and conflicts of interests, elements not necessarily present in other types of studies⁽⁸⁾. However, no reviews were found investigating the effects of virtual reality on the social participation of subjects after stroke. Therefore, the objective of this study was to carry out a systematic review of the literature, searching for evidence of the effects of the use of rehabilitation based on virtual reality in the recovery of the social participation of hemiparetic individuals after stroke.

METHODS

Design

This study is a systematic review of the literature, with the objective of describe the evidence on the effects of the use of rehabilitation based on virtual reality in the recovery of social participation of hemiparetic individuals after stroke.

Procedures

An online search was performed in the databases Medline, CINAHL, Web of Science, LILACS and PEDro, using the combination of words “Virtual Reality, Rehabilitation, Stroke, Cva, Hemiplegia, Hemiparesis, Hemiparetic, Paresis, Plegia, Paretic, Ischemic and Hemorrhagic”, and their respective terms in Portuguese. Two authors performed the research independently, initially by analyzing the titles and abstracts of the found articles. Subsequently, among the papers selected, the complete texts were read. The final choice of included articles was completed after a third independent evaluator resolved the disagreements between the first two reviewers.

Inclusion Criteria

The included articles had therapy based on virtual reality as intervention in hemiparetic patients, after acute, subacute or chronic stroke, focusing on the outcomes related to social participation, without restrictions of age or gender of participants. Studies that evaluated the quality of life were also included as a possible outcome measure for social participation. There was no restriction on the publication date or language.

Data Collection

The data were extracted and arranged in a standard table, adapted from the Cochrane Collaboration. The information extracted from the studies was: study type, characteristics of

the included participants (as gender, age, sample size, among others), objective, intervention protocol (as duration, intensity, frequency, description of activities, among others), the used outcome measures and the found results.

Methodological quality

The methodological quality of the clinical trials included in this study was evaluated according to the PEDro scale, described in the Physiotherapy Evidence Database (www.pedro.org.au). The scale, composed of 11 items, was developed to classify the methodological quality of randomized clinical trials. Each item, except item 1, contributes one point to the full scale score, ranging from 0 to 10 points. The score used will be the one displayed at the website database. The scores of studies not included in the PEDro database or not punctuated will be performed by the authors of this study, based on the scale made available by the database.

RESULTS

The electronic search conducted by the authors resulted in 2485 articles. Of these, 2156 were excluded after reading the titles and 317 after reading the abstracts. Of the 12 potentially eligible papers remaining, one was excluded after reading the full text because it was not in fact a randomized clinical trial. Manual search did not return any jobs. Thus, a total of 11 articles were included in the present review^(3,6,7,9-16) (Figure 1).

The selected studies were listed in Table 1, all of them being randomized, with scores ranging from 5 to 8 on the PEDro scale. Samples ranged from 18 to 235 subjects, totaling 600 participants, including acute, subacute and chronic stroke. The participants had a mean age ranging from 18 to 69 years, with 376 men, all hemiparetic due to stroke.

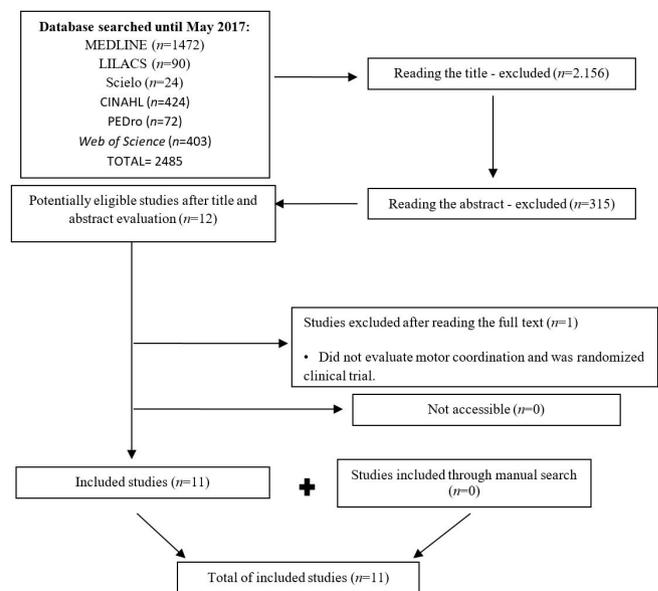


Figure 1. Flowchart for inclusion and exclusion of studies.



Table 1. Synthesis of the evaluated studies.

Studies / PEDro Score	Sample	Objective	Intervention	Instruments of assessment of social participation	Results
Adie <i>et al.</i> , 2017 7	235 subjects with chronic CVA. Intervention group n=117 66.8 ±14.6 years Control group n=118 68.0 ±11.9 years	To investigate the effectiveness of Nintendo Wii in improving the function of the affected UL and in the quality of life of the subjects after the CVA.	The IG performed daily exercises with the Nintendo Wii, using Wii Sports, with simulation of bowling, tennis, golf and baseball. The sessions lasted 60 minutes, 6 days a week for 6 weeks. The control group was oriented to only perform a list of home exercises for the UL during the same period.	Stroke Impact Scale (59-item scale with a 0-100 score) and EuroQol-5 Dimension (25-item questionnaire with a 1-5 score)	There was improvement in outcomes related to the quality of life of the subjects in the experimental group, but without significant differences when compared to the control group.
Choi <i>et al.</i> , 2016 7	24 patients with ischemic CVA. Intervention group n=12 61.0±15.2 years Control group n=12 72.1±9.9 years	To develop an exercise program based on virtual reality for post-stroke patients, and evaluate the feasibility and effectiveness of this program.	The IG performed 10 sessions with 1h of occupational therapy (30min of conventional OT and 30min of UL rehabilitation) using a smartphone and a tablet, 5 days a week, for 2 weeks.	EuroQol-5 Dimension (25-item questionnaire with a 1-5 score)	There was improvement in outcomes related to the quality of life of the subjects in the experimental group, but without significant differences when compared to the control group.
Fan <i>et al.</i> , 2014 5	20 patients with CVA Intervention group with Nintendo Wii n=5 56.9±14.9 years Conventional treatment group n=5 66.8±10.6 years Placebo group n=5 67.2±15.2 years Control group n=5 66.6±12.7 years	To verify the effects of a treatment, based on virtual reality, on motivation and motor capacity of stroke patients.	During 3 weeks, subjects underwent 1-hour sessions, 3 times a week, using 2 to 3 Wii Sports Resort games.	Stroke Impact Scale (59-item scale with a 0-100 score)	There was a significantly greater improvement in outcomes related to the quality of life of the subjects in the experimental group when compared to the results of the other groups.
Faria <i>et al.</i> , 2016 5	18 patients with CVA. Experimental group n=9 Mean of 58 years Control group n=9 Mean of 53 years	To verify if the therapy based on virtual reality is more effective than the conventional therapy in the cognitive rehabilitation of post CVA patients.	The intervention consisted of 20 sessions of 20 min, distributed between 4-6 weeks, involving the virtual simulation in which memory, attention, visuospatial abilities and tasks of executive function were part of the accomplishment of ADL.	Stroke Impact Scale (59-item scale with a 0-100 score)	There was a significantly greater improvement in the outcomes related to the quality of life and social participation of the subjects of the experimental group when compared to the results of the other groups.
Kong <i>et al.</i> , 2016 5	105 subjects post subacute CVA. Experimental group n=33 58 ± 9.1 years Conventional therapy group n=34 59 ±13.6 years Control group n=35 55.8 ± 11.5 years	To compare the effectiveness of a therapy based on virtual reality with the use of Nintendo Wii and conventional therapy in UL recovery after CVA.	Experimental and conventional therapy groups were submitted to 12 sessions of 1-hour treatment, 4 times a week for 3 weeks. The experimental group involved the use of Wii Sports games, selected according to the preferences of the subjects and their abilities. The use of the affected UL was mandatory.	Stroke Impact Scale (59-item scale with a 0-100 score)	There was no significant improvement in quality of life or social participation in the experimental group when compared to the other groups.



Table 1. Continued...

Studies / PEDro Score	Sample	Objective	Intervention	Instruments of assessment of social participation	Results
Lee <i>et al.</i> , 2016 8	26 subjects with chronic CVA Experimental group n=13 66.46 ± 7.26 years Group therapy group n=13 69.92 ± 7.18 years	To compare the effects of a rehabilitation program based on virtual reality with the rehabilitation in the function of UL, ADLs and QOL in subjects with chronic CVA.	During 8 weeks, participants from both groups underwent a 30-minute rehab program, 3 times a week. The experimental group used games involving movement of almost all joints of the UL in all planes of movement.	<i>Short Form Health Survey (SF-12)</i> (concise version of the SF-36, a 12-item questionnaire with a 0-100 score)	There was no significant improvement in quality of life or social participation in the experimental group when compared to the other groups.
Ribeiro <i>et al.</i> , 2015 7	30 patients with hemiparesis due to CVA Experimental group n=15 Mean of 52.8 years Conventional therapy group n=15 Mean of 53.7 years	To compare the effects of the use of Nintendo Wii and conventional physiotherapy in improving sensorimotor function and quality of life in patients with hemiparesis.	The subjects were submitted to 2-month intervention, with 1-hour sessions, 2 times a week. The sessions consisted of virtual games of tennis, boxing, soccer, among others, with progressive increase of the difficulty.	Health Survey questionnaire SF-36 (36-item questionnaire with a 0-100 score)	There was no significant improvement in quality of life or social participation in the experimental group when compared to the other groups.
Saposnik <i>et al.</i> , 2010 5	22 patients with up to 6 months of CVA Intervention with virtual reality group n=11 Mean of 55.3 years Recreational therapy group n=11 Mean of 67.3 years	To compare the viability, safety and efficacy of the use of virtual reality with Nintendo Wii in comparison to recreational therapy in the motor improvement of subjects after CVA.	Intensive program of 8 sessions of rehabilitation of 60min, flexibly distributed over 2 weeks. The Nintendo Wii was used, with games involving flexion, extension and rotation of the shoulder, flexion and extension of elbow and pronation, supination, flexion and extension of the wrist.	Stroke Impact Scale (59-item scale with a 0-100 score)	There was a significantly greater improvement in all outcomes related to the quality of life and social participation of the individuals in the experimental group when compared to the results of the other groups.
Shin <i>et al.</i> , 2016 8	46 subjects with hemiparesis due to CVA Experimental group n=24 57.2 ± 10.3 years Conventional therapy group n=22 59.8 ± 13.0 years	To verify the effects of a rehabilitation program based on virtual reality combined with standard occupational therapy on UL function and quality of life of post-stroke subjects.	Subjects underwent a 4-week individual rehabilitation program with 20 sessions of 30min focused on the distal end of paretic UL. Exercises were performed with the use of a biofeedback system (RAPAEL Smart Glove™).	Stroke Impact Scale (59-item scale with a 0-100 score)	There was a significantly greater improvement in all outcomes related to the quality of life and social participation of the individuals in the experimental group when compared to the results of the other groups.
Shin <i>et al.</i> , 2015 6	32 patients with hemiparesis due to chronic CVA Experimental group n=16 53.3±11.8 years Control group n=16 54.6±13.4 years	To determine if rehabilitation based on virtual reality games can improve the function of UL and the quality of life and depression of hemiparetic individuals.	20 sessions of 30min of conventional therapy with a 30-minute therapy based on virtual reality with the use of the RehabMaster™ software, for 4 weeks, 5 times a week.	Health Survey SF-36 questionnaire (36-item questionnaire with a 0-100 score)	There was no significant improvement in quality of life or social participation in the experimental group when compared to the other groups.
Simsek <i>et al.</i> , 2015 7	42 subjects with subacute CVA Experimental group n=20 54.15 ± 20.29 years Group therapy based on the Bobath concept n=22 61.5 ± 11.63 years	To investigate the effects of Nintendo Wii in the training of daily activities and the quality of life of patients with subacute CVA.	Rehabilitation program using the Wii Sports and Wii Fit games for 10 weeks, 3 times a week with sessions of 45-60 minutes. The games had the objectives of promoting UL training and balance.	Nottingham Health Profile (38-item questionnaire with a 0-38 score)	There was no significant improvement in quality of life or social participation in the experimental group when compared to the other groups.



All subjects in the experimental groups were submitted to interventions that included some kind of virtual reality interface. In four of the eleven studies were used as a rehab feature the games of the Nintendo Wii®. In the other studies, were used interfaces of non-commercial developed with the collaboration of the authors themselves. The minimum period of intervention reported was 2 weeks, and the maximum period was 8 weeks, with sessions of 30 and 60 minutes, 2 to 7 times a week. All participants performed tasks involving the compulsory use of upper limbs, as well as specific tasks of each study (gait, balance and others) according to the outcomes investigated by the authors. In addition to outcomes related to upper limb function, all studies also analyzed outcomes related to quality of life and social participation of the participants, which is the focus of interest of this review. The instruments used to assess social participation/quality of life were: Stroke Impact Scale (SIS), EuroQol-5 Dimension (EQ-5D 3L), Short Form Health Survey (SF-12), Health Survey SF-36 questionnaire (SF-36) and Nottingham Health Profile (NHP).

DISCUSSION

This study aimed to investigate the effects of the use of rehabilitation based on virtual reality in the recovery of the social participation of hemiparetic individuals after stroke. The analyzed studies show that although there seems to be benefits of using virtual reality in global aspects of hemiparetic patient recovery, such as in motor function, the results are still not consistent regarding social participation.

Of the included studies, four showed a significant improvement in the outcome of interest^(6,7,13,15). In the others, either there was no improvement or it was not relevant when compared to the gains obtained by the subjects in the control groups or those submitted to other types of intervention that did not involve virtual reality training. Fan *et al.* attributed the gains of the patients to the motivational factor of virtual reality and to the fact that the games are closer to the actual movement required for the proposed tasks than other therapies⁽⁶⁾. Whereas Faria *et al.* established a relationship between quality of life, social participation and adequate global cognitive functions, and also affirmed that positive results in the use of therapy based on virtual reality may be related to the fact that it represents a context closer to the real⁽⁷⁾. In spite of this, the authors admitted that the work lacks complementary information on the performance of patients in real factual tasks related to social participation after the intervention period. Lastly, Shin *et al.* cited the positive reinforcement of games through visual feedback and task specificity as relevant factors, but does not establish a direct relationship between these elements and the efficacy of virtual reality in improving quality of life⁽¹⁵⁾.

A possible explanation for the difference between the results found is the heterogeneity in the methods of the found articles. Although all clinical trials are randomized, there is

considerable difference in sample size, virtual reality interface used and type of task or exercises performed in the interfaces. In addition, there are studies with only experimental and control groups and studies with at least one more group with individuals undergoing some other intervention. Among the studies that did not find significant differences between the analyzed groups, the reasons cited most frequently by the authors for this result are reduced sample sizes, short intervention time and no follow-up^(10,12,14), as well as lack of specificity of the proposed exercises⁽³⁾ and even stroke time^(11,14). According to Lee *et al.*, the presence in the experimental group of subjects with a lesion time greater than seven years may have influenced the results, since, according to the authors' justification, gains in quality of life would tend to be higher in patients with a shorter stroke time⁽¹¹⁾.

Other studies show similar results. In a review carried out by Palma *et al.* it was investigated the general effects of virtual reality use in post-stroke patients considering the domains of the International Classification of Functioning, Disability and Health⁽¹⁷⁾. It was included 54 studies with a total of 1811 participants. The authors verified that the results of the use of virtual reality are still not conclusive in what refers to the domains of social participation and activity. The work discusses that in addition to the recent use of this resource, the specific influence on social participation is complex because it involves cultural and motivational factors and it is not yet possible to establish a direct relationship between the improvement of the structural aspects of the body and the behavioral improvement, since there are still few studies that deal with the topic⁽¹⁷⁾.

In other populations and health conditions, such as in Parkinson's disease, Alzheimer's disease and cerebral palsy, the use of virtual reality specifically with the objective of promoting gains in quality of life and social participation also presents few studies available, and almost always the theme is treated as a secondary outcome. Most studies are still concerned with control of motor learning, muscle strength, gait quality and cortical reorganization, and results related to quality of life are still inconclusive^(18,19). They also cited the importance of virtual reality as a resource that may present differentials in relation to others during the rehabilitation process by promoting motivation, being more playful and possibly more functional, but they emphasize the need for further studies on the subject⁽¹⁸⁻²⁰⁾.

The limitations of this study were the reduced sample of the studies, the moderate methodological quality, and very heterogeneous training protocols regarding equipment, time, frequency and duration of training, comparison, among others. Systematic and continuous comparison with a single resource or therapy or always with a placebo group would allow the observation of more consistent results regarding the real benefits of using virtual reality for the investigated outcomes.



CONCLUSION

This systematic review demonstrates that the use of virtual reality can bring benefits to the rehabilitation of hemiparetic individuals, being a promising resource. However, in relation to social participation, which was the outcome of interest in this review, the results are still not conclusive, demonstrating the need for more studies on the subject, allowing reviews covering works with more homogeneous and adequate methodologies and, consequently, greater accuracy in results.

AUTHORS' CONTRIBUTION

KKPM elaborated the design of the study; LCQ, KKPM and PRA carried out the search and collection of data; LCQ, KKPM and PRA wrote and revised the manuscript. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that there was no conflict of interest.

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