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Non-immersive virtual reality therapy in post-stroke patients a quick review

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Abstract. *Worldwide stroke is a major cause of long-term disability. As new technologies emerged in neurorehabilitation, from robotic to virtual reality therapies, we aimed to highlight the novelty and research methodology in the use of non-immersive virtual reality in the physical rehabilitation of post-stroke patients. A quick literature review was performed by querying Web of Science database, using 'non-immersive', 'virtual reality' and 'stroke' as keywords. Twenty-seven papers resulted from the query, after refining the results by the last five years and open access papers resulted in twelve articles selected for analysis. The inclusion criteria for the review were: rehabilitation technology and post-stroke patients. The exclusion criteria were linked with commercial virtual reality technology, speech or psychological interventions, and review papers. All the abstracts were assessed regarding the inclusion and exclusion criteria and seven papers were included in the review. Although virtual reality technology has developed and expanded in recent years, its application in rehabilitation medicine still requires further research, due to the variety of the software and hardware used and the necessary clinical trials. A more concise framework for the protocol of use of non-immersive virtual technologies used in rehabilitation is needed.*

Keywords: virtual reality, non-immersive, technology, rehabilitation

Introduction

Stroke is one of the leading causes of disability in the world. For stroke survivors to reduce their disability, they must go through a rehabilitation process that aims to regain independence and improve their quality of life. Using Virtual Reality (VR) technology facilitates the patients' guidance in the rehabilitation process and improve their receptivity in performing repetitive exercises.

VR therapy is an innovation in rehabilitation. As a primary substrate, an interface can connect specific virtual environment and the patient, which implements real-time simulation of activities or an environment and allows user interaction by multiple sensory means.

VR therapy is used to improve conventional therapies, promoting longer training sessions and considered an attractive way to research and recover, as it can provide both patients and therapists with additional feedback during recovery therapy. It raises the difficulty of therapy dynamically, increases the motivation and direct involvement of the patient *(Maggio et al., 2019; Mirelman etal., 2009; Lhose et al., 2013; Shizard et al., 2012).*

Before implementing VR Rehabilitation therapy, the therapist must choose the type of VR used for patients. The two categories most often used in rehabilitation are the types: immersive and non-immersive.

The immersive VR style is usually delivered through a head-mounted device and creates a realistic user environment. The other type of VR is non-immersive. This branch of VR usually comes in the form of a video game device *(Cameirão et al., 2010; Proffitt & Lange, 2015).*

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This method is proposed to optimize the therapeutic effects due to its possibilities to increase patients' recovery potential over a while significantly *(Adamovich et al., 2009).* Also, virtual reality is intended for cognitive and proprioceptive development by performing personalized movement patterns increased progressively in complexity and complexity, which requires concentration, distributive attention, and a high level of patient involvement *(Faria et al., 2016).*
This therapy is composed of a wide range of clinical games, with varying levels of difficulty, focused on different aspects of recovery (touch, manipulation, mobilization) *(Laver et al., 2017).*
Since the existing literature regarding the use of VR therapy in the post-stroke population, we aimed to identify the research using dedicated VR technology in post-stroke rehabilitation.

Methodology

We have SCI-EXPANDED, SSCI, A & HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC, databases, using 'non-immersive', 'virtual reality' and 'stroke' as keywords. Twenty-seven papers resulted from the query, after refining the results by the last five years and open access papers resulted in twelve articles selected for analysis. The inclusion criteria for the review were: rehabilitation technology and post-stroke patients. The exclusion criteria were linked with commercial virtual reality technology, speech or psychological interventions, and review papers. All the abstracts were assessed regarding the inclusion and exclusion criteria and seven papers were included in the review.

Results and discussions

Three papers address the use of NVIR through dedicated technology. One paper is a pilot study on the use of NVIR as home therapy after an initial training session, the second paper reports superior effects of using dedicated NVIR associated with conventional physiotherapy in recovering functionality and neuro-motor capacity of the upper extremity in post-stroke patients. However, the paper does not have a distinct approach regarding the subacute or chronic stage of post-stroke patients, and the analysis of the results does not make any difference from this point of view. Only one research had control and experimental groups, where VR therapy was compared with standard physiotherapy. From other four papers, one study suggests that the use of non-dedicated NVIR (video-games) is not superior to other recreational physical activities along with standard physiotherapy in recovering the functionality of the upper extremity after stroke. From the seven papers analysed, only two of them approached dedicated NVIR technology (Kiper et al., 2020; Miclaus et al., 2020), and only one of them had control groups. However, in one research, the addressability was for the upper limb, while others addressed to the lower limb rehabilitation. Another protocol for a future trial is ongoing and the protocol proposed implies a VR dedicated technology for rehabilitation (Kilbride et al., 2018). Some authors emphasized that there are no protocols for using NVIR in post-stroke patients, and the results suggest that VR has the potential to become a useful intervention for the outpatient rehabilitation of stroke survival patients. (Saposnik et al., 2016; Aramaki et. al., 2019; Gandhi et al., 2020). Other research addresses the measurement of imbalance in post-stroke patients using non-dedicated NVIR and using as a control group 20 healthy subjects, making difficult to identify the potential of VR training in balance rehabilitation (Bonuzzi et al., 2020). Only one paper is a literature review, which analyses non-dedicated NVIR in the recovery of post-stroke upper extremity functionality, which

suggests that VR commercial games are effective in neuro-motor rehabilitation along with standard physiotherapy (Ghandi et al., 2020)

Table no 1. Papers included in the research

Study		No. of patients	*Gender n*		Mean age in years (± SD if available)	Time since Stroke (± SD if available)	Intervention	Outcomes
			M	*F*				
Saposnik et al., 2016	E	71	46	25	62 (13)	> 2 months	VR Wii therapy-ten sessions, 60 min each, over a 2-week period.	Chedoke-McMaster, WMFT, BBT, SIS, FIM, MRS, Dynamometer, BI.
	C	70	48	22	62 (12)	> 2 months	received recreational activity-ten sessions, 60 min each, over a 2-week period.	
Kilbride et al., 2018	E	30	NA	NA	NA	NA	participants recruited to use the Neurofenix, VR rehabilitation platform at home for 7 weeks (1 week training, 6 weeks exercise).	FM-UE, ARAT, MAL, MAS, PROM, FSS-7, QOL, VAS
							**Non-randomized research It involves a training home visit followed by a 1-week training phase and a subsequent 6-week training phase.	
Aramaki et. al., 2019	E	10	6	4	41.3/12.11	> 2 months<24 months	X Box and Microsoft Kinect technology and games-40 minutes/day, three days/week, for 12 weeks.	COPM, COPM satisfaction
	C	0	0	0	0	none	none	
Gandhi et al., 2020	E	NA	NA	NA	NA	<6 months	Computer game-based therapy for post-stroke upper extremity rehabilitation (non VR)	ARAT, WMFT, BBT, MAL, FMA, SSQOL, IMI, BDI, SULCS, NHP
	C	NA	NA	NA	NA	<6 months	Conventional Physiotherapy	
Bonuzzi et al,. 2020	E1*	10	7	3	62.8 (± 9.8)	32.4 (± 33.9) m	balance task for thirty minutes, four consecutive day using Nintendo Wii "Tilt Game"	MMSE, BECK, FMS, BERG, FRT
	E2**	10	5	5	67.5 (± 8.8)	35.9 (± 48.1)		
	C***	20	12	8	64.2 (±7.6)	none		
Miclaus et al., 2020	E1	6	2	4	NA	0-6 months	VR dedicated rehabilitation therapy and dexterity exercise for UE- 60 minutes/day- two weeks	AROM, PROM, FM-UE, FIM, FRT, MAS, MRS
	E2	20	5	15	NA	>6 months< 4 years		
	C1	5	1	4	NA	0-6 m	Standard physiotherapy for UE, 60 minutes/day- two weeks	
	C2	21	7	14	NA	>6 m< 4 years		
Kiper et al., 2020	E1	31	26	5	60.02 (17.58)	<6 m	VR dedicated rehabilitation therapy, 15 sessions, 5 days/week, 1 h/day.	FM-LE, MAS< BBS, FIM, FAC, MAS, 10 MWT
	E2	28	8	20	60.59 (11.14)	>6m		

E= Experimental Group, C=Control Group, M=Male, F=Female, SD=Standard Deviation, d= days, m=months, WMFT= Wolf Motor Function Test, ADL=activity of daily living, BBT= Box and Block Test, SIS= Stroke Impact Scale, MRS=Modified Rankin Scale, BI= Barthel Index, FM-UE=Fugl Meyer Upper Extremity Assessment, FIM= Functional Independence Measure, ARAT= Action Research Arm Test, MAL= Motor Activity Log, AROM=Active Range of Motion, PROM= Passive Range of Motion MAS=Modified Asworth Scale, FSS-7= Fatigue Severity Scale, QOL= Quality of Life, VAS= Visual Analogue Scale, COPM= Canadian Occupational Performance Measure, SS-QOL= Stroke specific QOL, IMI= Intrinsic motivation inventory, BDI=Beck depression inventory, SULCS=Stroke Upper Limb Capacity Scale, NHP=Nottingham Health profile, MMSE= Mini Mental State Evaluation, BECK= Beck Depression Inventory, FMS= Sensory Fugl Meyer Scale, BERG/BBS= Berg Balance Scale Score, FRT= Functional Reaction Test, FM-LE= Fugl Meyer Lower Extremity Assessment, FAC= Functional Ambulation Category, 10MWT= 10-metre walk test, * Right Injury, ** Left Injury,*** Healthy subjects, NA=Not available. Source: Web os Science Core Collection papers

Since information technology is still expanding and VR, both immersive and non-immersive technologies are used both in clinical practice and medical education, the interdisciplinary approach needs to be included in the next strategies for post-stroke patients and neurological rehabilitation. (Patrascu et al., 2014; Repanovici et al., 2009, Todorova et al., 2014, Drugus et al., 2017, Rogozea et al., 2010)

Conclusion

Although VR therapy is gaining ground in post-stroke rehabilitation, the lack of clinical randomized trials and protocols which shall guide physiotherapists and rehabilitation physicians worldwide makes it challenging to use this type of therapy to its full potential. The research is mixed, and the heterogeneity of trials makes it difficult to determine scientific conclusions. Further clinical trials and systematic reviews should focus on rehabilitation VR technology and not commercial gaming technology.

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