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VIRTUAL REALITY THERAPY FOR UPPER EXTREMITY FUNCTIONS FOLLOWING STROKE. A SYSTEMATIC REVIEW

Gurkeerat Gill, Vilma Dudonienė
Lithuanian Sports University

ABSTRACT

Background. After a stroke attack, the majority of the individuals suffer from the upper extremity functional impairments. Recently, virtual reality has indicated promising positive functional outcomes in stroke patients. To identify the efficacy of virtual reality therapy, there is an essential need to measure its effectiveness on the parameters of evidence-based science.

Design. Systematic review of literature.

The aim. To analyse the effectiveness of the virtual reality therapy on the upper extremity functions after stroke.

Methods. A database of articles published from 2010 to 2018 was compiled by using the keywords: stroke, stroke rehabilitation, virtual reality, virtual reality therapy, upper limb, and upper extremity. After careful screening of the articles, the articles, which met the selection criteria, were included. Fourteen studies involving 416 patients in total were analysed.

Findings. Virtual reality was found to be a remarkable rehabilitation therapy. All methods that were applied in virtual reality therapy on the patients suffering from Ischemic and Haemorrhagic stroke provided significant positive results in the functionality of the upper extremity.

Conclusion. In all cases, virtual reality was found to be a highly effective and useful tool for rehabilitation in stroke patients.

Keywords: stroke, virtual reality, stroke rehabilitation, upper extremity.

INTRODUCTION

Stroke is an extensive worldwide health related disorder, which has exceedingly long-lasting detrimental effects on the common life of a human being (Langhorne et al., 2011). Stroke is the third most prevalent cause of death and lifelong disability (Bonita et al., 2004). Statistically, by evaluating the number of stroke patients from previous years, it has been estimated that there will be nearly 70 billion stroke survivors by 2030 (Feigin et al., 2014). Unfortunately, coming back to daily life activities without any adverse effects after a stroke is near to impossible. It restricts a person in all physical, mental and psychological aspects of life.

Following stroke, reduction in physical activity leads to a further decline in the quality of life (Rand et al., 2009). Hence, rehabilitation assists the stroke survivor with the proper guidance to regain mobility, functional independence, and to be able to be socially inclusive again (Darekar et al., 2015). It has been recorded that there are greater upper limb deficits after the stroke. Approximately 85% of stroke survivors suffer from upper extremity deficits. The impairment and disruption in the upper extremity remain 3-6 months post stroke in 55–75% of the population. This dysfunction considerably limits daily life activities performed by patients. Therefore, according to the needs of post-stroke conditions, patients are entirely dependent upon rehabilitation for maximal recovery. Efficacious intervention of rehabilitation is believed to reduce complications and relieve burden from patients and society. In addition, it declines the mortality rate (Jang, 2013).

There are numerous types of rehabilitation approaches available, including physiotherapy, occupational therapy, and virtual reality therapy. Within these various rehabilitation approaches, virtual reality simulates functional activity, which is, the most fundamental and crucial step in stroke rehabilitation (da Fonseca et al., 2017). Virtual reality facilitates the stroke patient with an environment which develops a virtual interaction between the user and the artificial conditions in the surrounding. Virtual reality interventional training has the capacity to make incremental intensity. In addition, it offers numerous possible tasks and helps to keep the patient motivated because of the playful characteristic of this therapy (Zheng et al., 2015). Virtual reality is considered safe, enjoyable, and motivating, and at the same time allows testing the hypothesis that it promotes motor control (Timmermans et al., 2009).

The aim of this systematic review was to analyse the effectiveness of virtual reality therapy on upper extremity functions following stroke.

METHODS

Article Search. The articles were searched in PubMed and Science Direct research databases. The following keywords were used for the search of different studies: stroke, stroke rehabilitation, virtual reality, upper limb, upper extremity.

Article / Study selection. Selection criteria for the articles were as follows:

1. The study has to be a clinical trial (comparison between the pre and post treatment), or randomized controlled trial (clinical trial with a control group), pilot study (short-term study), or case study.
2. In the study, patients had to be be stroke survivors who had passed 3 months after the stroke attack.
3. Focus of the studies should be on the upper limb mobility and function.
4. Language of the studies should be English.
5. Full text article.
6. Articles published between 2010 and 2018 years.

Stream of the studies through the review. Subsequent to examining and screening the studies, 14 studies were selected for inclusion in the review. The stream of the studies through the review is shown in Figure 1.

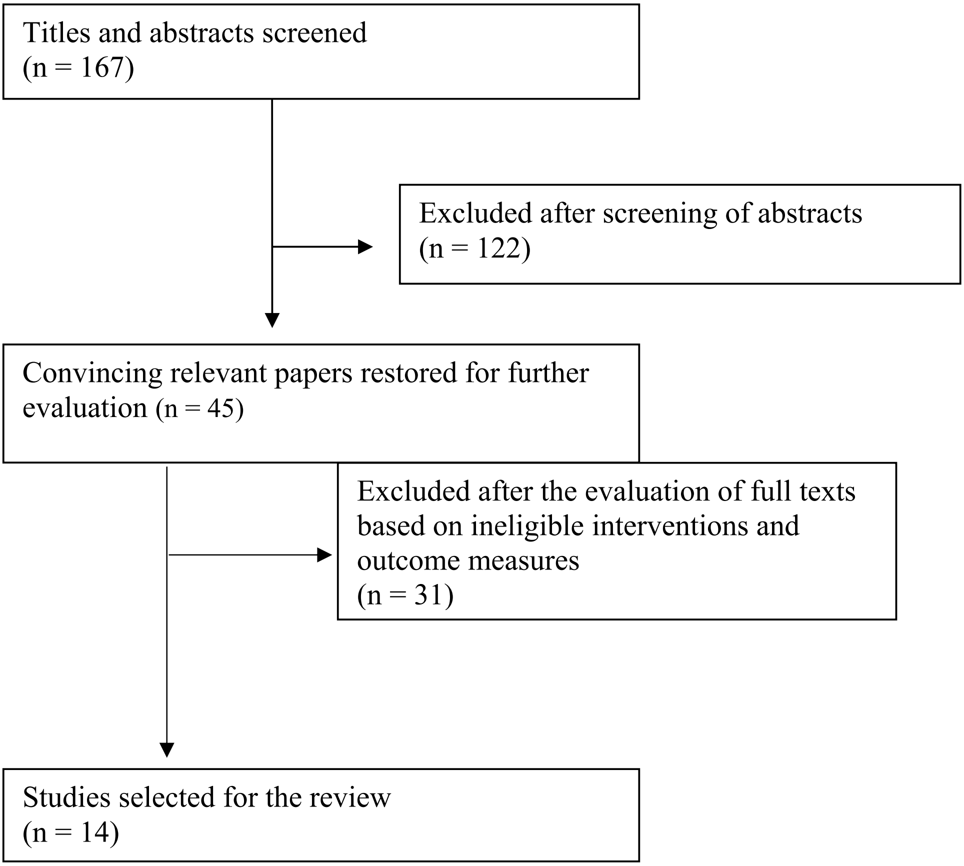

Figure 1. **Stream of the studies through the review**

REASEARCH RESULTS

Seven out of the 14 selected articles (50%) were randomized controlled trials, four selected articles (28.6%) were pre and post experimental, two – pilot studies and one – a case study (Table 1).

The total number of participants in all analysed studies altogether was 416. The age of the patients varied from 34 to 91 years. Patients were the survivors of ischemic and haemorrhagic stroke. The summary of the number of participants, gender, age, and stroke type is presented in Table 1.

Table 1. **Characteristics of the analysed articles**

Author and year	**Parti-cipants (n)**	**Gender**	**Age (yrs. ± SD)**	**Stroke type**
Adams et al., 2017, pre and post experiment	15	6M, 9F	41–91	Ischemic and Haemorrhagic
Aşkın et al., 2018, RCT	40	28M, 12 F	34–72	Ischemic and haemorrhagic
Perez-Marcos et al., 2017, pilot study	10	4M, 6 F	34–72	Ischemic and haemorrhagic
Gonçalves et al., 2018, pre and post experiment	18	10M, 8F	55.5± 13.9	Ischemic stroke
Afsar et al., 2018, RCT	35	20M, 15F	E – 69.42 ± 8.55, C – 63.44 ± 15.73	Ischemic and haemorrhagic
Kim et al., 2016, case study	15	10 M, 5F	52–77	Ischemic and haemorrhagic
Kiper et al., 2018, RCT	136	80M, 56 F	63.9 ± 14.1	Ischemic and haemorrhagic
Lee et al., 2018, RCT	30	18 M, 12 F	E – 61.80 ± 6.80 C – 61.33 ± 8.44	Ischemic and haemorrhagic
Lee et al., 2016, RCT	18	8 M, 10 F	E – 69.2 ± 5.51 C – 73.13 ± (8983)	Ischemic and haemorrhagic
Lee et al., 2018, RCT	41	23 M, 18 F	E – 49.5± 13.7, C – 46.1 ± 13.0	Ischemic and haemorrhagic
Liao et al., 2018, pre and post experiment	10	5M, 5F	50 to 76	Ischemic and haemorrhagic
Llorens et al., 2017, pre and post experiment	7	5 M, 2 F	55.9 ± 8.1	Ischemic and haemorrhagic
Park, J. H., Park, J. H., 2016, RCT	30	16 M, 14 F	E – 61.6 (5.34), C – 62.0 (4.29)	Ischemic and haemorrhagic
Stockley et al., 2017, pilot study	11	5 M, 6F	E – 58 to 82. C – 44 to 82	Ischemic and haemorrhagic
Total	416	M–57% F–43%	34–91 yrs. Average – 62	**93%** Ischemic and haemorr-hagic**, 7%** Ischemic

Note. M – male; F – female; E – experimental; C – control; RCT – randomised controlled trial; D – standard deviation.

Different kinds of intervention strategies were used in different studies while focusing on the upper extremity. Some of the studies used only virtual reality-based activities as intervention, whereas some used virtual reality-based activities in addition to conventional therapy (CPT). Interventions of analysed articles are presented in Table 2.

Table 2. **Interventions of analysed articles**

Author and year	Intervention	Number of sessions
Llorens et al., 2017	Reversible A-B-A Design. 3–5 times in a week. Phase A: 60 min Conventional Physical Therapy (CPT) Phase B: 20 min Virtual Reality Therapy (VRT) + 40 min CPT	75
Adams et al., 2017	Virtual ADL practice. 3 sessions per week, 1-hour duration. Total interventional therapy period was 8 weeks.	24
Kim et al., 2016	Virtual Therapy: 40–50 min/day, 3 days/week. Total time of intervention was 8 weeks.	
Aşkın et al., 2018	Group A: 20 sessions of PT (5 days/week, 4 weeks) + 20 sessions of VRT training (1 hour a day, 5 days/week, and 4 weeks). Group B: 20 sessions of PT. (5 days/week, 4 weeks). Total time of intervention was 4 weeks.	20
Gonçalves et al., 2018	Standard rehabilitation (30 min PT and 30 min OT). Subsequently, 60 minutes VRT. Total sessions were 20 (2 sessions per week).	
Afsar et al., 2018	EG: 60 min conventional therapy + 30 min Virtual Reality Therapy (5 times a week). CG: 60 min conventional therapy (5 times a week). Total time for intervention was 4 weeks.	
Kiper et al., 2018	Experimental group: 2 hours daily, 1-hour VRT and 1-hour CPT, 5days per week, for 4 weeks. Conventional Therapy group: 2 hours daily, 5 days per week. Total time for intervention was 4 weeks.	
Lee et al., 2018	Experimental group: VT + FES, 30 minutes, 5 times week. Control group: FES, 30 minutes, 5 times a week. Total time of intervention was 4 weeks.	
Park J. H. , Park J. H., 2016	Experimental group: VRT 30 min + Mental Practice 5 min. Control group: VRT 30 min. All participants had 20 sessions (5 in a week). Total duration of intervention was 4 weeks.	

Author and year	Intervention	Number of sessions
Perez-Marcos et al., 2017	VRT training. 2 sessions per week. (Each session consisted of one hour). Total time of intervention was 5 weeks.	10
Lee et al., 2018	Experimental group: PT and OT, 30 min per session, twice a day, 5 days in a week. Additionally, VRT, 30 min per session, 3 days per week. Control group: PT and OT, 30 min per session, twice a day, 5 days in a week. Total time for intervention was 5 weeks.	25
Lee et al., 2016	In experimental group, VT given for 30 min a day, 3 days a week, for the period of 6 weeks. In control group, bilateral upper limb training was given 30 min a day, 3 days a week, for the period of 6 weeks. Both groups were receiving the additional conventional therapy for 30 min a day, 3 days a week, for the period of 6 weeks.	18
Stockley et al., 2017	Experimental group: VRT 30 min + Therapeutic gym exercises. Control group: Therapeutic gym exercises. Total duration of intervention was 12 weeks.	
Liao et al., 2018	Virtual Reality Therapy: 45–60 min each session, 3 days a week. Total duration of intervention was 4–5 weeks (depending upon availability).	12–15
Average	**Frequency – 3 d/week** **Duration of interventions – 5 weeks.**	**23.3 ± 15.44**

Note. VRT – virtual reality therapy; CPT – conventional physical therapy; PT – physical therapy; OT – occupational therapy; ADL – activities of daily living; FES – functional electrical stimulation; VT – virtual therapy.

Thirty-one different outcome measures were used across all these studies. Twenty-six were used for upper extremity motor functions, one for neurological characteristic assessment, one for functional characteristics, one for training assessment, one for quality of movement, and one for fatigue assessment. For the most part, all the studies measured the upper extremity functional outcomes. Every study used at least three or more different outcome measures. All outcome measurements were performed only for upper extremity. Different kinds of outcomes used in the studies are listed in Table 3.

Table 3. **List of the outcome measures**

Author and year	**Outcome Measures**
Adams et al., 2017	Upper extremity motor functions = FMA (Primary outcome measure), Wolf Motor Function Test (WMFT) – Functional Assessment Score (FAS) (Secondary outcome measures). Calculation of the time for average task = WMFT – TIME (Secondary outcome measures).
Aşkın et al., 2018	Upper extremity motor functions = FMA (Primary outcome measures). Muscle activation and spasticity = BRS, MAS (Secondary outcome measures). Manual fine motor skills = BBT (Secondary outcome measures). Motor function of arm =MI (Secondary outcome measures). AROM (Secondary outcome measures).
Perez-Marcos et al., 2017	Upper Extremity motor functions = FMA (Primary and Secondary outcome measures). Muscle strength = mMRCS (Secondary outcome measures). Functional independence = FIM (Secondary outcome measures). Pain rating = VAS (Secondary outcome measures). AROM (Secondary outcome measures).
Gonçalves et al., 2018	Assessment of neurological characteristics = NIHSS, BI, mRS, SSS. Assessment of upper extremity functional characteristics: CMcMS, BBT.
Afsar et al., 2018	UE motor functions = FMA (Primary outcomes). Manual fine motor skills = BBT (Secondary outcome measures). Functional independence = FIM (Secondary outcome measures).
Kim et al., 2016	Upper extremity motor functions = FMA. Unilateral upper limb motor functions =MFT. Manual fine motor skills = BBT Performance of ADL = MBI.
Kiper et al., 2018	Upper extremity motor functions = FMA (Primary outcome). Functional independence = FIM (Secondary outcome measures). Assessment of neurological characteristics = NIHSS (Secondary outcome measures). Measurement of pain and tiredness = ESAS (Secondary outcomes).
Lee et al., 2018	Upper extremity motor functions = MFT. Balance of postural stability = mFRT, Wii Balance Board.
Lee et al., 2016	Upper extremity motor functions = Jebsen-Taylor Hand Function Test. Manual fine motor skills = BBT Upper extremity muscle strength = manual muscle testing.

Author and year	Outcome Measures
Lee et al., 2018	Upper extremity motor functions = FMA, WMFT – FAS (Primary outcome) Calculation of the time for average task = WMFT – TIME (Primary outcome). Manual fine motor skills = BBT (Secondary outcome).
Liao et al., 2018	Upper extremity motor functions = FMA, WFMT – FAS, AROM. Calculation of the time for average task = WMFT – TIME (Primary outcomes). Hand functions and movement measurement = Stroke Impact Scale-Hand function, confidence of arm and hand movement (Secondary outcomes).
Llorens et al., 2017	Upper extremity motor functions = FMA, WMFT – FAS. Calculation of the time for average task = WMFT – TIME.
Park, J. H., Park, J. H., 2016	Upper extremity motor functions = FMA; Manual fine motor skills = BBT; Quality of movement in UE = The quality of movement subscale of the Motor Activity Log.
Stockley et al., 2017	Upper Extremity motor activity and function = motor activity log, Manual fine motor skills = BBT; Fatigue measurement =Fatigue severity scale.

Note. FMA – Fugl-Meyer Assessment; BBT – Box and block test; AROM – active range of motion; BRS – Brunnstrom Recovery Stage; MAS – Modified Ashworth Scale; MI - Motricity index; WMFT - Wolf Motor Function Test; FAS – Functional Assessment Score; UE – upper extremity; mMRCS – Modified Medical Research Council Scale; VAS – visual analog scale; FIM – Functional Independence Measure; NIHSS – National Institutes of Health Stroke Scale; BI – Barthel Index; SSS – Scandinavian Stroke Scale; CMcMS – Chedoke-McMaster scale; ESAS – Edmonton Symptom Assessment Scale; mFRT – modified Functional Reach Test; MFT – Manual Function Test.

Effects of the interventions on patients following stroke in all the studies came as positive as interventions stayed successful to induce the betterment in patients in all accepts of the mobility and functionality of the upper extremity.

To investigate the effects of the intervention more accurately and statistically, we searched for the most commonly used measurement tools in the studies. After carefully contemplating on the outcome measurements, we found that FMA (Fugl-Meyer Assessment) and BBT (Box and Block Test) were used frequently for the outcome measurements. FMA was widely used to measure the upper extremity motor functions, whereas BBT was used to measure the fine motor skills.

FMA was applied in 9 out of 14 studies. After the anatomization of the statistical results for FMA, it was noticed that only 2 studies (Aşkın et al., 2018; Llorens et al., 2017) had the p value higher than 0.05, which made the differences of outcome measures statistically insignificant. Whereas, remaining 7 studies had the p value lower than 0.05, which revealed the results as statistically valid (Table 4).

Table 4. **The statistical values for the outcome measure Fugl-Meyer Assessment**

Author and year	Virtual reality		Controls		P value between groups after intervention
	Before	After	Before	After	
Adams et al., 2017	20 (14–34)	28 (18–38)	–	–	0.001*
Aşkın et al., 2018	39.0 (22.0–56.0)	42.0 (23.0–58.0)	39.5 (19.0–58.0)	31 (19.0–58.0)	0.319
Perez-Marcos et al., 2017	42.0 (24.75–53.0)	45.5 (27.0–57.0)	–	–	0.007*
Afsar et al., 2018	24.32 ± 7.87	43.05 ± 12.59	19.88 ± 3.79	34.44 ± 10.53	0.04
Kim et al., 2016	33 (14–61)	49 (15–66)	–	–	0.001*
Kiper et al., 2018	37.99 ± 17.76	47.71 ± 15.74	43.15 ± 17.21	46.29 ± 17.25	0.001
Liao et al., 2018	37.40 ± 17.83	5.70 ± 3.47	–	–	0.001*
Llorens et al., 2017	12.9 ± 2.5	18.0 ± 5.35	12.6 ± 2.4	17.6 ± 5.1	0.08
Park J. H. , Park J. H., 2016	49.3 ± 1.2	54.4 ± 1.9	48.9 ± 1.4	53.1 ± 2.4	< 0.05

Note. * – p < 0.05 –between before and after intervention within group.

Statistical outcomes of the studies are shown in Table 5.

Table 5. **Statistical outcomes of the studies**

No	Author and Year	Comparison between the groups	Statistical Outcome after intervention/between the groups
1	Adams et al., 2017	✗	P < 0.05
2	Aşkın et al., 2018	✓	P > 0.05
3	Perez-Marcos et al., 2017	✗	P < 0.05 except FIM (Functional independence)
4	Gonçalves et al., 2018	✗	P < 0.05
5	Afsar et al., 2018	✓	P > 0.05except FIM (Functional independence)

No	Author and Year	Comparison between the groups	Statistical Outcome after intervention/between the groups
6	Kim et al., 2016	✗	P < 0.05 except BBT (Manual fine motor skills)
7	Kiper et al., 2018	✓	P < 0.05
8	Lee et al., 2018	✓	P < 0.05
9	Lee et al., 2016	✓	P < 0.05
10	Lee et al., 2018	✓	P < 0.05 except BBT (Manual fine motor skills)
11	Liao et al., 2018	✗	P < 0.05 except CAHM (Hand function measurement)
12	Llorens et al., 2017	✓	P > 0.05
13	Park J. H. , Park J. H., 2016	✓	P < 0.05
14	Stockley et al., 2017	✓	P > 0.05

DISCUSSION

In this systematic review, 14 studies were examined to appraise the effect of virtual reality exercises on the functions of the upper extremity following stroke. The outcome of the analysis indicates the enhancement of upper extremity functional performance with long-term positive effects.

R. J. Adams et al. (2017) investigated the therapeutic influence of virtual reality training on the recovery of upper extremity functions, and found that virtual reality was related to significant clinical improvement in motor function measures in stroke patients. D. Perez-Marcos et al. (2017) discovered that virtual reality system positively affected the functions of the upper extremity in moderate to severe chronic stroke patients, but this study also emphasized that the progression in the active range of motion in the upper extremity was also depends on the intensity of the training. High intensive training results in better outcomes. Therefore, this study concluded that with the help of virtual reality, it was possible to enhance the functions of the upper extremity in stroke survivors, even in the early and chronic phases of the stroke.

In the same token, J. Kim et al. (2016) demonstrated that virtual reality had definitive positive effects on the upper limb motor functions, and on the activities of the daily life of chronic stroke survivors. Repetitive movements and exercises with proper intensity were key factors for the recovery of the motor functions of the upper extremity and better daily life activities. This study showed the significant improvement in daily life activities with no adverse effects. This makes virtual reality safer and more reliable. Furthermore, W. W. Liao et al. (2018) reported the substantial amelioration in the shoulder and elbow functions after virtual reality therapy. More interestingly, participants found the virtual reality therapy as friendly, enjoyable and amusing. Patients also appreciated the visual and auditory feedback, which was an integral part of the virtual reality training. It was found that as the therapy was more centralized on the sequential practice of the movement patterns, in the better the improvement in the functions of the upper extremity. Participants gave a self-review about the virtual therapy as entertaining and intriguing. Overall, this study confirmed that the stroke patients from the various levels of the upper extremity movement ability can gain help and the benefit from the virtual reality.

The intervention plan in the studies mentioned above consisted only of virtual reality therapy exercises. By concluding the obtained results of the studies, results ascertained the effectiveness of virtual reality therapy. Virtual reality exercises had a highly positive effect while being entertaining and captivating for the patients, supporting the first hypothesis addressed by the current review.

A. Aşkın et al. (2018) compared the results and the effects of virtual reality and conventional therapy on the improvement of upper extremity functions differently in different groups of stroke patients. This study observed enhancement in shoulder flexion, abduction, external rotation, and elbow extension found in both groups of the therapy, but enhancement in upper extremity functions was higher in the virtual reality therapy group as compared to the conventional therapy group. Therefore, this study firmly concluded that virtual reality contributed more to the improvement of upper extremity functions and AROM of the affected limbs in chronic stroke patients in contrast of CT. Additionally, Afsar et al. (2018) also came to the same conclusions as A. Aşkın et al. (2018). The study showed noteworthy recovery in the functions of the upper extremity in the virtual reality therapy group in comparison to the CT group.

R. C. Stockey et al. (2017), M. M. Lee et al. (2018), and P. Kiper et al. (2018) also demonstrated similar results with their experimental studies. The results showed conclusively that while both the virtual reality therapy group and the conventional therapy group made improvements in the functions of the upper extremity, the subjects who were taking the virtual reality therapy surpassed the CT group. P. Kiper et al. (2018) also added that virtual reality therapy was highly effective for both types of strokes, ischemic and haemorrhagic. Moreover, the effectiveness of virtual reality was not affected by factors like age and sex, and also took in the account that virtual reality therapy was safe and reliable. R. C. Stockey et al. (2017) added that while virtual reality was free of adverse effects, patients also felt beneficial outcomes in cognition and perception. M. M. Lee et al. (2018) reported that virtual reality therapy also raised motivation of patients in comparison to the boredom of regular therapies, and such factors enhanced the rate of participation and compliance from the side of the patient.

The interventions in the above-mentioned studies were compared between different therapies. Results from these studies concluded that the patients who participated in the virtual therapy group gained higher benefits as compared to the patients who participated in the CT groups.

R. Llorens et al. (2017) designed an intervention program with the combination of conventional therapy and virtual reality therapy to observe the effectiveness of both therapies together. The study detected that the combination of virtual reality and CT confirmed the favourable and promising results for the recovery of the upper limb functions. The patients in this study were not only chronic stroke survivors but also suffering from severe hemiparesis.

Similarly, M. G. Goncalves et al. (2018) designed the experiment with the combination of virtual reality therapy and CT. This study assessed the effects of VRT and CT rehabilitation on the number of stroke patients. This combination of the therapies attested and presented the highly positive results on the functions of the upper extremity. Combining virtual reality with conventional therapy proved to be successful. Importantly, and interestingly, virtual reality exhibited appositive impact on the brain neuroplasticity, which is the significant factor in reducing motor deficits. This study noticed positive effects on cognition, physical functions as well as improvement in the patient's perception of the quality of life.

The studies mentioned above used strategies to make a therapy plan with the combination of VRT and CT. Results from these studies concluded that the combination of the VRT and CT had a positive effect on treatment which lead to improvement of the upper extremity functions even in severe cases of the stroke. As such, the third hypothesis addressed by this review was supported.

This systematic review concluded and specified that the virtual reality therapy for functionality of the upper limbs after the stroke could facilitate the patient with short-term to long term improvements. Virtual reality therapy is effective for both types of strokes, ischemic and haemorrhagic.

CONCLUSIONS

1. It was observed that virtual reality therapy had a highly positive impact on upper limb functions, activities of daily life, confidence and motivation in patients.

2. It was found that virtual reality appeared to be more effective in the restoration and improvement of the functions of the upper extremity in comparison to other therapies

3. Virtual reality therapy combined with the conventional therapy was found to have a beneficial impact in the improvements of upper extremity functionality.

4. The clinical significance of the findings from this study is that virtual reality therapy is a promising new approach towards the rehabilitation of the upper extremity functions in stroke patients.

REFERENCES

Adams, R. J., Lichter, M. D., Ellington, A. et al. (2017). Virtual activities of daily living for recovery of upper extremity motor function. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 26 (1), 252–260.

Afsar, S. I., Mirzayev, I., Yemisci, O. U., Saracgil, S. N. C. (2018). Virtual reality in upper extremity rehabilitation of stroke patients: A randomized controlled trial. *Journal of Stroke and Cerebrovascular Diseases*, 27 (12), 3473–3478.

Aşkın, A., Atar, E., Koçyiğit, H., Tosun, A. (2018). Effects of Kinect-based virtual reality game training on upper extremity motor recovery in chronic stroke. *Somatosensory & Motor Research*, 35 (1), 25–32.

Bonita, R., Mendis, S., Truelsen, T., Bogousslavsky, J., Toole, J., Yatsu, F. (2004). The global stroke initiative. *The Lancet Neurology*, 3 (7), 391–393.

da Fonseca, E. P., da Silva, N. M. R., Pinto, E. B. (2017). Therapeutic effect of virtual reality on post-stroke patients: Randomized clinical trial. *Journal of Stroke and Cerebrovascular Diseases*, 26 (1), 94–100.

Darekar, A., McFadyen, B. J., Lamontagne, A., Fung, J. (2015). Efficacy of virtual reality-based intervention on balance and mobility disorders post-stroke: A scoping review. *Journal of Neuroengineering and Rehabilitation*, 12 (1), 46.

Feigin, V. L., Parmar, P. G., Barker-Collo, S. et al. (2014). Geomagnetic storms can trigger stroke: Evidence from 6 large population-based studies in Europe and Australasia. *Stroke*, 45 (6), 1639–1645.

Gonçalves, M. G., Piva, M. F. L., Marques, C. L. S. et al. (2018). Effects of virtual reality therapy on upper limb function after stroke and the role of neuroimaging as a predictor of a better response. *Arquivos de Neuro-Psiquiatria*, 76 (10), 654–662.

Jang, S. H. (2013). Diffusion tensor imaging studies on arcuate fasciculus in stroke patients: A review. *Frontiers in Human Neuroscience*, 7, 749.

Kim, J., Lee, M., Kim, Y., Eun, S. D., Yoon, B. (2016). Feasibility of an individually tailored virtual reality program for improving upper motor functions and activities of daily living in chronic stroke survivors: A case series. *European Journal of Integrative Medicine*, 8 (5), 731–737.

Kiper, P., Szczudlik, A., Agostini, M. et al. (2018). Virtual reality for upper limb rehabilitation in subacute and chronic stroke: A randomized controlled trial. *Archives of Physical Medicine and Rehabilitation*, 99 (5), 834–842.

Langhorne, P., Bernhardt, J., Kwakkel, G. (2011). Stroke rehabilitation. *The Lancet*, 377 (9778), 1693–1702.

Lee, M. M., Lee, K. J., Song, C. H. (2018). Game-based virtual reality canoe paddling training to improve postural balance and upper extremity function: A preliminary randomized controlled study of 30 patients with subacute stroke. *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research*, *24*, 2590.

Lee, S. H., Lee, J. Y., Kim, M. Y. et al. (2018). Virtual reality rehabilitation with functional electrical stimulation improves upper extremity function in patients with chronic stroke: A pilot randomized controlled study. *Archives of Physical Medicine and Rehabilitation*, 99 (8), 1447–1453.

Lee, S., Kim, Y., Lee, B. H. (2016). Effect of virtual reality-based bilateral upper extremity training on upper extremity function after stroke: A randomized controlled clinical Trial. *Occupational Therapy International*, 23 (4), 357–368.

Liao, W. W., McCombe Waller, S., Whitall, J. (2018). Kinect-based individualized upper extremity rehabilitation is effective and feasible for individuals with stroke using a transition from clinic to home protocol. *Cogent Medicine*, 5 (1), 1428038.

Llorens, R., Borrego, A., Latorre, J. et al. (2017, June). A combined transcranial direct current stimulation and virtual reality-based intervention on upper limb function in chronic stroke survivors with severe hemiparesis. In *2017 International Conference on Virtual Rehabilitation (ICVR)* (pp. 1–7). IEEE.

Park, J. H., Park, J. H. (2016). The effects of game-based virtual reality movement therapy plus mental practice on upper extremity function in chronic stroke patients with hemiparesis: A randomized controlled trial. *Journal of Physical Therapy Science*, 28 (3), 811–815.

Perez-Marcos, D., Chevalley, O., Schmidlin, T. et al. (2017). Increasing upper limb training intensity in chronic stroke using embodied virtual reality: A pilot study. *Journal of Neuroengineering and Rehabilitation*, 14 (1), 119.

Rand, D., Weiss, P. L. T., Katz, N. (2009). Training multitasking in a virtual supermarket: A novel intervention after stroke. *American Journal of Occupational Therapy*, 63 (5), 535–542.

Stockley, R. C., O'Connor, D. A., Smith, P. et al. (2017). A mixed methods small pilot study to describe the effects of upper limb training using a virtual reality gaming system in people with chronic stroke. *Rehabilitation Research and Practice*. Retrieved from https://doi.org/10.1155/2017/9569178

Timmermans, A. A., Seelen, H. A., Willmann, R. D., Kingma, H. (2009). Technology-assisted training of arm-hand skills in stroke: concepts on reacquisition of motor control and therapist guidelines for rehabilitation technology design. *Journal of Neuroengineering and Rehabilitation*, 6 (1), 1.

Zheng, C. J., Liao, W. J., Xia, W. G. (2015). Effect of combined low-frequency repetitive transcranial magnetic stimulation and virtual reality training on upper limb function in subacute stroke: A double-blind randomized controlled trail. *Journal of Huazhong University of Science and Technology [Medical Sciences]*, 35 (2), 248–254.

VIRTUALIOSIOS REALYBĖS TERAPIJA RANKŲ FUNKCIJAI PO INSULTO. SISTEMINĖ STRAIPSNIŲ APŽVALGA

Gurkeerat Gill, Vilma Dudonienė
Lietuvos sporto universitetas

SANTRAUKA

Pagrindimas. Po insulto dauguma žmonių kenčia nuo rankų funkcinių sutrikimų. Pastaraisiais metais nustatyta, kad virtualioji realybė teigiamai veikia insultą patyrusių žmonių funkcinius rodiklius. Virtualiosios realybės terapijos veiksmingumas turi būti patvirtintas mokslu grįstais įrodymais.

Tikslas – išanalizuoti virtualiosios realybės terapijos veiksmingumą ligonių, patyrusių galvos smegenų insultą, rankų funkcijai.

Dizainas. Sisteminė literatūros apžvalga.

Metodai. Duomenys surinkti iš duomenų bazių, straipsniai publikuoti tarp 2010 ir 2018 metų. Ieškoma su šiais raktažodžiais: insultas, insulto reabilitacija, virtualioji realybė, virtualiosios realybės terapija, rankos. Atidžiai patikrinus straipsnius, atitinkančius vertinimo kriterijus, jie buvo įtraukti ir išanalizuoti. Nagrinėta 14 straipsnių, kuriuose analizuojama 416 insultą patyrusių ligonių rankos funkcija.

Tyrimo rezultatai. Virtualioji realybė buvo puikus gydymo būdas. Visi metodai, taikomi virtualiosios realybės terapijos metu, pagerino ligonių, sergančių išeminiu ir hemoraginiu insultu, rankų funkcionalumą.

Išvados. Visais atvejais virtualioji realybė nustatyta kaip labai veiksminga ir naudinga priemonė insultą patyrusiems ligoniams.

Raktažodžiai: insultas, virtualioji realybė, reabilitacija po insulto, ranka.

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