An overview of applying virtual reality intervention to improve functional outcomes for post-stroke patients in rehabilitation

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Summary

Post-stroke patients may have to experience a wide range of impairments or deficits such as movement dysfunction or cognitive impairments that require early rehabilitation management to get better recovery. The rapid development in technology facilitates for many aspects in medicine and rehabilitation. In recent years, virtual reality intervention has been a novel therapy improving functional outcomes among post-stroke patients (Lee, Park, & Park, 2019). Specifically, virtual reality technology has created a life-like environment to stimulate physical activities that may encourage stroke survivors to take part in activities willingly through interaction in virtual environment which is quite similar with the real world (Kizony, Levin, Hughey, Perez, & Fung, 2010). This overview is going to analyse the effectiveness of virtual reality intervention in improving functional outcomes for post-stroke patients and give some recommendations in clinical practice.

Keywords: Rehabilitation, post-stroke, virtual reality intervention.

1. Upper limb function

Virtual reality intervention is an innovative approach to improving the upper limb function among post-stroke patients. Upper limb function impairments have negative impacts on the activities and participations domain based on the World Health Organisation's International Classification of Functioning Disability and Health (ICF) (Stucki et al, 2002). These effects comprised domestic life, social and civil life, sport and recreation, and the art as well as the emotion, cognitive abilities, and behaviour. To support for the virtual reality intervention in post-stroke patients, Crosbie, Lennon, McGoldrick, McNeill, and McDonough (2012) conducted a randomized control trial in 18 post-stroke patients with hemiplegia to assess the effectiveness of virtual reality intervention on upper limb function. The intervention group received the virtual reality therapy and the control group received a conventional treatment in three weeks. Crosbie et al. (2012) found that the both groups improved 7- 8 points in upper limb Motricity Index and 4 points in the Action Research Arm Test. Similarly, Fan et al (2014) undertook a pilot randomized controlled trial to determine the improvements of an affordable of off-the-sheft virtual reality on the improved intrinsic motivation and motor capacities in reaching task in 20 post stroke patients with hemiparesis. The participants were allocated randomly into 4 groups: Virtual reality via Wii gaming, conventional therapy, a placebo board game and no treatment with four weeks follow-up. The results of this trial indicate that the biceps and flexor carpi radialis showed significantly shorter time-to peak contractions before and after treatment in the virtual reality group, while, there is no significant difference in the conventional group. Additionally, the participants in the virtual reality group experienced higher intrinsic motivation compared to those in other groups. To reinforce the practice based- evidence of virtual reality, Kiper, Agostini, Luque-Moreno, Tonin, and Turolla (2014) undertook a randomised controlled trial with the greater number of participants applying virtual reality environment for restoration of upper extremity functional impairments in post- stroke survivors. This trial included 44 patients divided randomly into experimental and control group. After 4 weeks of intervention, the virtual reality environment group highlighted the significant improvements in Fugl-Meyer upper extremity scale and Functional Independence Measure score and kinematics outcomes compared to traditional rehabilitation group. Like previous studies, the sample size in this trial do not meet the sample size calculation with α = 0.05 and β = 0.8. However, the results of this trial showed the potential impact of virtual reality in improving the functional outcomes among stroke survivors. Kiper et al (2018) conducted a trial with the greater number of participants in order to provide strong evidence that met the power for the sample size. 136 post-stroke patients within one year of stroke onset were recruited and allocated randomly in the virtual reality environment combined with conventional rehabilitation group and the conventional group. Both groups received 2 hours treatments per day in 5 days per week in 4 weeks. Kiper et al (2018) found that both groups showed the improvements after treatments in the Fugl-Meyer upper extremity scale and Functional Independence Measure score and kinematics outcomes, but the virtual reality environment combined with conventional rehabilitation group had a better outcome compared to conventional rehabilitation group. In the same line with other studies, Brunner et al (2017) undertook a randomized control trial in 120 post-stroke patients with upper limb extremity motor impairment in subacute phase in 5 rehabilitation centers. The virtual reality intervention in this trial was called YouGrabber system that contains a large number of therapy models including whole arm movement, reaching and grasping therapy, selective finger ability and etc. This software may provide similar physical therapies compared to what physiotherapists can do for stroke survivors with arm deficits. After 4 weeks treatment, participants in virtual reality group improved the Action Research Arm Test score from 12 ± 11 to 17 ± 13, while the improvements in conventional therapy group were from 13 ± 10 to 17 ± 13. They state that virtual reality intervention was equally effective in improving upper limb extremity function compared to additional conventional training among stroke suffers in the subacute phase. The results from this trial suggests that virtual reality may be used as a motivating training alternative in standard rehabilitation. To date, Mekbib et al (2020) did a meta-analysis on 27 randomized clinical trials reporting that virtual reality showed significant improvement in upper limb function among post-stroke patients. So, from these results of many trials, virtual reality intervention may improve the upper limb function and could substitute for conventional therapy.

2. Waking ability and gait function

In terms of improving walking function and gait rehabilitation, virtual reality intervention also brings better outcomes for stroke survivors. Post-stroke patients with paralysis or muscle weakness may experience falls that resulted in fracture from 23% to 50% among stroke suffers (Harris, Eng, Marigold, Tokuno, & Louis, 2005). Additionally, falls efficacy had a moderate correlation with activities daily living performance, balance and cognitive ability (K. Cho, Yu, & Rhee, 2015). A wide range of trials indicates that virtual reality intervention is also a novel intervention that could potentially improve the postural ability and walking function. Due to the interaction and feedback from the virtual reality systems, participants develop a plenty of techniques to improve posture and gait ability. Kim, Jang, Kim, Jung, and You (2009) carried out a randomized control trial to investigate the effectiveness of virtual reality intervention on balance and gait ability in 24 post-stroke patients with chronic hemiparesis. The control group and the intervention group received the conventional therapy in 40 minutes a day, 4 days a week for 4 weeks, while the intervention group received additional 30 minutes per day with virtual reality intervention. The results of this trial demonstrate that there were significant improvements in Berg Balance scale cores, balance and dynamic balance angles in the virtual reality group compared to the control group. Similarly, the experimental group had significant ameliorations in the gait performance test compared to the control group. Although, the results of this trial give a strong evidence to support for the effectiveness of virtual reality in rehabilitation for hemiparesis stroke survivors, it contained several limitations. The duration of treatment between two groups was not equal and the time follow-up is quite short. Jung, Yu, and Kang (2012) experimented a randomized control trial in twenty-one stroke survivors who experienced falls after stroke in their history. This study aimed to determine the effects of the virtual reality treadmill intervention in balance and balance self-efficacy based on a timed up and go test (TUG) and the activities- Specific Balance Confidence (ABC) scale. Twenty patients were randomly allocated into two groups and the evaluator was blinded to eliminate the biases in assessments. The patients in the interventional group wore a head mounted device walking on the treadmill and watched a virtual environment (a park stroll) through the screen of the head mounted device. The participants in control group was treated by treadmill training without virtual reality environmental on the same schedule with the experiment group. After 3 weeks, there was a statistical difference in improving balance and balance self-efficacy in treadmill in virtual reality group compared with treadmill group. Although, this trial had a small sample size (20 participants) and undertook in short duration, the results of this trial provide a clinical meaning of the evidence- based practice when the outcomes between two groups had significant difference. To reinforce the effectiveness of virtual reality intervention in the improvements of gait in post-stroke patients, Moreira, de Amorim Lima, Ferraz, and Benedetti Rodrigues (2013) conducted a systematic literature review with four randomized control trials. They concluded that virtual reality was a potential intervention to improve the gait of post- stroke patients. In addition, post- stroke patients need to achieve the independence in real life to reintegrate community more easily. Management the cognition while walking is a key to deal with this problem. So, recently, the treadmill virtual reality combined with performed cognitive load task has shown the superiority in ameliorating walking function of stroke suffers in chronic phase compared with the pure treadmill virtual reality after 4 weeks of the intervention (Cho KH, Kim, Lee, & Lee, 2015). The intervention included a video recording of a real societal situation such as ‘a cross walk, garden and marketplace, and the virtual environment” playing in 30 minutes that was combined with cognitive load task namely “memory, arithmetic, and verbal tasks” (Cho KH et al, 2015). The author concluded that virtual reality training with cognitive load might be used to achieve the walking ability independently in post-stroke patients in the ongoing phase. However, the sample size in this trial is small that may have an influence on the validity of the results. In addition, the participants in this trial included post-stroke patients with high functioning, hence the results were not representative for all stroke patients. Similarly, In, Lee, and Song (2016) state that virtual reality reflection therapy (VRRT) improved the postural balance and gait ability statistically of stroke suffers. VRRT is a modified version of virtual reality that a mirror therapy was based on visual illusion. This intervention allows patients to be able to observe the reflected imagine of their normal limb as the affected one while taking part in the repetitive exercise in the affected lower limb. As a result, a dynamic balance ability may be produced that influences positively on gait ability. The participants were allocated randomly into the virtual reality group (13 patients) and the control group (12 patients). The intervention group received 30 minutes conventional therapy added 30 minutes with VRRT per day, while the control group received 30 minutes conventional therapy and 30 minutes with a placebo of VRRT program. After 4 weeks, the VRRT group showed significant improvements in Berg Balance Scale, the functional Reaching Test and the Timed Up and Go test, postural sway and 10 metre walking velocity test compared to control group. In same line with other studies, Bang, Son, and Kim (2016) conducted a trial to compare the improvements in balance and walking for stroke survivors between the virtual reality training using Nintendo a Wii intervention and the treadmill therapy. Twenty participants were divided randomly into two groups that underwent 40 minute exercise program three times a week within eight weeks. The results revealed that the virtual reality group experienced significant improvements in the stance phase, swing phase, and cadence. Bang et al (2016) suggested that virtual reality training may be useful for people who want to improve the balance and walking ability. To date, Fishbein, Hutzler, Ratmansky, Treger, and Dunsky (2019) reported that dual-task walking using virtual reality showed significant improvement in walking and balance for post-stroke patients compared to single task treadmill. In general, virtual reality intervention alone or combined with treadmill can significantly improve the balance and gait for post- stroke patients.

3. Conclusion

To sum up, virtual reality intervention can provide for post-stroke patients with sensory stimulation, a more immersive environment and real-time feedback. A wide range of interventions has applied from virtual reality therapy to a combination between virtual reality environment with treadmill that demonstrate better outcomes or equal results compared with conventional therapy. All trials showed that the virtual reality intervention can improve the upper limb function as well as the lower limb function via improving the balance and gait ability. A majority of the studies were randomized controlled trials, so the results of these trials are valid and meaningful for evidence- based practice. However, most of trial do not mention about the cost for this intervention as well as its adverse events. So, it is hard to give the implication for practice when comparing the cost-effectiveness of this intervention to conventional therapy. In addition, the sample size in most of trial is quite small, and the duration of treatment is short. Hence, the researchers should carry out trials with greater number participants and longer follow-up time.

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