The Effect of Virtual Reality on Rehabilitation Post Stroke Patients: An Integrative Review

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Abstract

Background: Post stroke patients need to be rehabilitated to improve their body functions to performed daily activity. Mostly conventional rehabilitative therapies were monotonous which may decrease patient's motivation due to repetitive and simple movements. Virtual reality intervention as technology based therapy showing a promises approach that could be applied in stroke rehabilitation. Objective: This literature review aimed to identify various virtual reality interventions and its effectiveness for rehabilitation stroke patients. Methods: An integrative literature review was conducted to search the publication in the data base of Cumulative Index to Nursing and Allied Health Literature (CINAHL and Pubmed in period during 2009 to 2019. The inclusion criteria were randomized control trial, studies that used virtual reality in rehabilitation patients with stroke; free full text articles, and used English language. The exclusion criteria was pilot study. Finally a total of 13 relevant studies included in analysis. Results: All of the articles were randomized control trials published in 2018 or later. The sample size were adults or elderly varied from 20-80 years old with stroke. The sample size varied from 20 to 121 respondents. Nintendo Wii was the most common used as VR intervention. Conclusions: This review shows evidences that suggested the effectiveness of virtual reality intervention in rehabilitation patients with stroke. Most studies support the beneficial effects of VR on upper limb motor recovery. Other studies reported the improvement in balance, walking, lower extremity muscle activation, visual perception, brain activity and activity daily living in stroke patients.

Keywords: virtual reality, stroke patients, rehabilitation.

1. Introduction

Stroke is the second leading cause of death worldwide [1]. In Indonesia, the newest data showed increase of the prevalence of stroke from 7% in 2013 to 10.9% in 2018 [2]. Sensory and motor disturbances and language disorders included as clinical features of stroke [3]. Study from [4] reported more than 85% of patientsexperience hemiplegia immediately after stroke. In United State, from the 795.000 newstroke patients, 26% remain disabled in basic activities of daily living and 50% have reduced mobility due to hemiparesis [5].
Post stroke patients need to be rehabilitated to improve their body function to perform daily activity. However, most of the conventional rehabilitative therapies were monotonous which may decrease patient's motivation due to repetitive and simple movement. To maintain patient participation during the long-term rehabilitation process, the training method should be functional and effective and should not be monotonous; rather, it should encourage patient's interest [6]. With recent developments of relevant computer programs, new methods of rehabilitation exercise are being introduced. Virtual reality intervention as technology-based therapy showing a promise approach that could be applied in stroke rehabilitation. Virtual reality indicates a type of interactive simulation using computer hardware and software, in which users can have close-to-reality experiences [7]. By performing exercise through VR, patients showed improved muscle strength, range of motion, and motor control [8]. To date, most of the studies conducted in Korea and Western country and there was no study reported using VR for rehabilitation patients with stroke in Indonesia. Considering explanation above, the aimed of this study was to review and analyze various virtual reality intervention and its effectiveness for rehabilitation in patients with stroke. This study aimed to review various virtual reality intervention and its effectiveness for rehabilitation in patients with stroke. The element of virtual reality intervention were identified and discussed. Recommendation for nursing practice to improve patient's rehabilitation through virtual reality intervention were provided.

2. Methods

We undertake an integrative review. The process of searching relevant studies was performed in May 2019 using two electronic database (e.g., CINAHL and PubMed). The keyword such as virtual reality, rehabilitation, and stroke patients were used to search the data. The inclusion criteria of the studies were: randomized control trial, studies utilized virtual reality in rehabilitation patients with stroke; free full text articles, and used of English language. Time of publishing the articles restricted from 2009 to 2019. The study was conducted by two independent researchers, using the same keyword and filters in two database. A total of 640 articles were found. Thirteen articles were met the criteria and were related to the study purposes.

3. Results
3.1. The characteristic of included studies

The information regarding the title of the studies, year of publication, authors, participants, various VR intervention, outcome measurement, and results of the studies were provided in Table 1. Most of the studies published in 2016 (46.15%) and the others published in 2012, 2015, and 2018 (53.85%). Majority of the studies conducted in South Korea (n=10). Generally, the VR interventions were individual based. All studies selected were randomized controlled trial (RCT). Moreover, the number of participants varied from 18-121. There is no gender restriction regarding the sample composition.

**Table 1: Summary of selected studies including title, author/year of publication and VR intervention.**

<table>
<thead>
<tr>
<th>No</th>
<th>Title/ Year of Publication</th>
<th>Author</th>
<th>Participants</th>
<th>VR Intervention</th>
<th>Outcome Measurement</th>
<th>Results</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>The efficacy of interactive, motion capture-based rehabilitation on functional outcomes in an inpatient stroke population: a randomized controlled trial / 2018</td>
<td>John C., Emelyn J., Amy R., Kylie I., Anna M T., Michele L C., Stuart T S., Kiran D K A., &amp; Marie-Louise B.</td>
<td>Seventy three patients with infarct and hemorrhagic stroke who has decreased mobility.</td>
<td>iMCR (interactive motion capture-based rehabilitation) technology software (Jintronix™)</td>
<td>MMA for upper arm function</td>
<td>The participants improved limb function and time up and go (all p &lt; 0.04), upper in standing, sitting balance</td>
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<td>2</td>
<td>A low cost Kinect-based virtual rehabilitation system for inpatient rehabilitation of the upper limb in patients with subacute stroke/ 2018</td>
<td>Won-Seok K., Sungmin C., Seo H P., Ji-Yung L., SuYeon K., &amp; Nam-Jong P</td>
<td>23 patients with subacute stroke. The participants were divided into 2 groups: 11 participants to sham group and 12 participants to real group</td>
<td>Kinect-based VR system and Rehacom</td>
<td>FMA, Brunsmstrom stage for arm and hand, BBT</td>
<td>Upper limb showed significant improvement across times (P&lt;0.001)</td>
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<td>3</td>
<td>Effect of virtual reality games on strike patients’ balance, gait, depression and the interpersonal relationships/ 2015</td>
<td>Gui B S., &amp; Eun C P.</td>
<td>The participants were 40 patients with chronic stroke divided into 2 group Virtual Reality Group (VRG) and Ergometer Training Group (RTG)</td>
<td>Xbox Kinect</td>
<td>LOS, TUG</td>
<td>The VRG showed more significant increase in balance, gait abilities, interpersonal relationship and reduce depression (p&lt;0.05)</td>
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<td>4</td>
<td>Effect of a virtual reality video game exercise program on upper extremity function and daily living activities in stroke patients/ 2018</td>
<td>Ju-Hong K.</td>
<td>The participants were 24 hemiplegia patients with chronic stroke.</td>
<td>Wii Sport and Wii Fit software produced by Nintendo</td>
<td>FMA and MFT</td>
<td>The experimental group participants’ daily living activities improved after training (p&lt;0.001) The upper extremity function between the group was not significantly different (p&lt;0.05)</td>
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<tr>
<td>5</td>
<td>Effect of virtual reality-based rehabilitation on distal upper extremity function and health-related quality of life: a single-blinded, randomized control trial/ 2016</td>
<td>Joo-Ho S., Mi-Young K., Ji-Yeong I., Yu-Jin J., Suypng K., Soobin L., Beomjoo S., &amp; Younggeun C.</td>
<td>The participant were 46 patients with upper extremity deficit by stroke</td>
<td>RAPAEI Smart Glove™ (Neofect, Yong-in, Korea)</td>
<td>FMA, JTT, PPT, SIS</td>
<td>The Smart Glove Group was significantly effective than Conventional Group on distal extremity function. Using FM p= 0.006, JTT total score p= 0.032, PPT total score p= 0.018 and by using SIS total score p= 0.001</td>
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<td>6</td>
<td>Effect of a four-week virtual reality-based training versus conventional therapy on upper limb motor function after stroke: A multicenter parallel group randomized trial/ 2018</td>
<td>Corina S A., Kynan E., Zorica S., Irene T., Sandra S., Isabelle L., Ludvig S., Michael A M., Miura H., Martin L V., &amp; Daniel K.</td>
<td>The participants were 54 patients post stroke</td>
<td>You Grabber (now Bi-Manu-Trainer)</td>
<td>BBT, CAHAi, SIS</td>
<td>The experimental group showed higher improvement on the hand function, activities daily living and mobility index than conventional group by SIS (p=0.057)</td>
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<td>7</td>
<td>Efficacy and safety of non-immersive virtual reality exercising in stroke rehabilitation (EVREST): a randomized, multicenter, single-blind, controlled trial/ 2016</td>
<td>Gustavo S., Leonardo G C., Muhammad M., Sedeth P., Michelle P., Donna C., Jennifer S., Judith H., Peter N., Sean D., Yongchai N., Fellipe D I R., Lisandro O., Mindy L., Robert T., Ashley C., Kevin T., Andreas L., &amp; Mark B.</td>
<td>The participants were 121 patients with stroke</td>
<td>Nintendo Wii (Nintendo Co., Ltd, Kyoto, Japan)</td>
<td>WMFT</td>
<td>There was no significantly benefit between VR and recreational rehabilitation (p=0.93), even though the VR is safe.</td>
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<td>8</td>
<td>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/ 2016</td>
<td>Park, J. H., &amp; Park, J. H</td>
<td>Thirty subject with chronic stroke recruited. Each experimental and control group had 15 subjects.</td>
<td>Wii Sports and Wii Sports Resort games (the bowling, table tennis, and canoeing games) by Nintendo, Kyoto, Japan</td>
<td>FMA, BBT, MAL-QOM</td>
<td>Game-based virtual reality movement effective for functional recovery upper extremity (p &lt; 0.05). The effect will increase when it combined with mental practice.</td>
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<td>9</td>
<td>The effect of virtual reality-based eccentric training on lower extremity muscle activation and balance in stroke patients/ 2016</td>
<td>Park, S. K., Yang, D. J., Uhm, Y. H., Heo, J. W., &amp; Kim, J. H</td>
<td>Thirty chronic stroke patients (15 patients using a slow velocity eccentric training and 15 patients using a fast velocity eccentric training)</td>
<td>An Eccentron (BTE Technologies Inc., Hanover, MD, USA)</td>
<td>EMG, BioRescue</td>
<td>Lower extremity muscle and balance ability of the subjects improved after 8-weeks intervention with eccentric training using a slow velocity (p &lt; 0.05).</td>
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<td>10</td>
<td>Effect of virtual reality training using Nintendo Wii and treadmill walking exercise on balance and walking for stroke patients/ 2016</td>
<td>Bang, Y. S., Son, K. H., &amp; Kim, H. J</td>
<td>Forty stroke patients (20 in virtual reality training and 20 in treadmill exercise)</td>
<td>Wii-fit by Nintendo, Japan</td>
<td>Pedoscan, Smart Step</td>
<td>There were a significant differences in balance and walking after completing virtual reality training ($p &lt; 0.05$) and ($p &lt; 0.01$).</td>
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<td>11</td>
<td>Effect of virtual reality-based training and task oriented training on balance performance in stroke patients/ 2015</td>
<td>Lee, H. Y., Kim, Y. L., &amp; Lee, S. M.</td>
<td>Twenty four stroke patients randomly divided into virtual reality training group (n=12) and task oriented group (n=12)</td>
<td>Wii, Wii Balance Board and Wii Fit plus</td>
<td>FRT</td>
<td>Virtual reality training improve dynamic balance in patients with stroke ($p &lt; 0.0001$).</td>
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<tr>
<td>12</td>
<td>Effect of virtual reality based rehabilitation on upper extremity function and visual perception in stroke patients: A randomized control trial/ 2012</td>
<td>Cho, K., Yu, J., &amp; Jung, J</td>
<td>Twenty nine patients were randomly allocated into virtual reality group (n=15) and control group (n=14)</td>
<td>The Interactive Rehabilitation and Exercise System: bird and balls, coconuts, drums, juggler, conveyor, and soccer games</td>
<td>WMFT, MVPT</td>
<td>Upper extremity function recovery and visual perception showed significant improvement after VR intervention ($p &lt; 0.01$).</td>
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<tr>
<td>13</td>
<td>Effect of virtual reality-based bilateral upper-extremity training on brain activity in post stroke patients/ 2016</td>
<td>Lee, S., Kim, Y., &amp; Lee, B. H</td>
<td>Eighteen chronic stroke patients recruited (experimental group (n=10) and control group (n=8)).</td>
<td>virtual reality-based bilateral upper-extremity training (VRBT)</td>
<td>A QEEG-8 (Laxtha Inc., Daejeon, Korea)</td>
<td>Brain activity improved (FP1, FP2, Fp3, FP4) after VRBT training ($p &lt; 0.05$).</td>
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</table>

Note: MMA = Modified Motor Assessment Scale; FMA = Fugl-Meyer Assessment; BBT = Box and Block test; LOS = Limit of Stability; TUG = Time Up and Go test; MFT = Manual Function Test; JTT = Jabsen-Taylor hand function test; PPT = Purdue Pegboard Test; SIS = Stroke Impact Scale; WMFT = Wolf Motor Function Test; CAHA = Chedoke-McMaster, Arm and Hand Activity Inventory; MAL-QOM = The Motor Activity Log; EMG = MP100 surface electromyography; FRT = Functional Reach Test; MVPT = The Motor Free Visual Percepcion.

Various VR interventions, intervention protocols, main outcomes from virtual reality intervention in patients with stroke.
Other less frequent outcomes evaluated included depression and activity daily living.

NintendoWii was the common VR in the intervention protocol (5 studies). Regarding the intervention protocol, the length of each session varied from 30 minutes to 60 minutes. The duration of the intervention ranged from four to eight weeks. Some test and instruments were used to evaluate the participants in the studies. The most commonly used was the Fugl-Meyer Assessment (four studies), followed by Box and Block Test (two studies) and Wolf Motor Function Test (two studies).

4. Discussion

Virtual reality is technology that developed in recent years for health area especially in rehabilitation. The definition of virtual reality by Oxford dictionary is computer-generated simulation of a three-dimensional image or environment that can be interact with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors[14]. According to [15] virtual reality for rehabilitation more effective than traditional rehabilitation for developing excitement, physical and cognitive ability which include develop four specific rehabilitation outcomes: motor control, balance, gait, and strength. Supported by [16] virtual reality was recommended for developing motor function after stroke on rehabilitation phase.

The virtual reality which uses special electronic equipment with sensor in this study mostly used Nintendo Wii produced by Japan. The Nintendo Wii is one of device that provides motor function for rehabilitation. Some studies reported the advantages of Nintendo Wii such as relative affordable gaming console, can be performed at home as part of patients home rehabilitation program [17], easy to handle by therapist [18], variety of activities and games, enjoyable and increase patient motivation [19]. Hence, Nintendo Wii to be a choice for many patients with stroke in the rehabilitation phase.

The total of training time is an important element of virtual reality intervention. Previous study revealed increasing training dose improved the motor function [20]. Along with studies reviewed, the duration of the intervention varied from four to eight weeks with 30 to 60 minutes in each session gave beneficial effect in patient with stroke. The effects of the virtual reality for patient with stroke which commonly to improve limb function were improved muscle strength, range of motion and motor control. Moreover, the virtual reality brings others good impact such as improving visual perception. The improvement of visual perception was due to visual feedback from...
VR-based intervention. Besides, the impairment of stroke found in the overall of lobes causes malfunction of brain activities such as concentration, memory, problem solving skills [21], [22] found that significant effect of virtual reality on brain activity. Although limited study reported the effect virtual reality on brain activity, it can be recommended for the future research. Nevertheless, since the number of participants, the length of the duration and intensity were various, it makes the study less viable to generalize.

Fugl Meyer Assessment was the most frequent used outcome measurement, applied in 5 studies. Previous studies also reported that FMA was the most commonly used and relevant to assess the function of upper limb in patients with stroke [23], In 1970’s FMA was developed to measure impairments of sensory motor in stroke patients. The confident interval both intra and inter rater was high as outcome measurement in stroke patients. Five domains assessed through this test, including motor (assessment of upper extremity and lower extremity), sensory, balance, range of motion, joint pain [24].

One study found no significant difference between the intervention group and recreational group. It showed no significant different regarding hand function, grip strength, motor performance, and activity of daily living at the end of the session. In their study non-immerse virtual reality was used. They argued non-immerse virtual reality less beneficial than immerse virtual reality. In fact, non-immerse virtual reality are easier to deliver, low cost, less complex. The duration of the intervention also remained short. On the other hand, four selected studies used Nintendo Wii as intervention showed significant results.

5. Conclusion

This review shows evidences that suggest the effectiveness of virtual reality intervention in rehabilitation patients with stroke. For future recommendation, nurses especially in Indonesia could collaborate with other health care professional to develop virtual reality as intervention for rehabilitation patients with stroke. Research regarding the effectiveness of virtual reality in other malfunction area of the body caused by stroke should be also conducted in the future.

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Conflict of Interest

The authors have no conflict of interest to declare.

References


