Review Paper: Effects of Virtual Reality Therapy on the Balance and Health-Related Quality of Life of Patients With Stroke: A Systematic Review

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Abstract

Introduction: Stroke is one of the leading causes of death worldwide. Despite the glowing advancement of Virtual Reality Therapy (VRT), clear evidence about its effectiveness in stroke is still scarce. Hence it is essential to review the current information to provide up-to-date insight. Therefore the aim of this review is to evaluate the effects of VRT on the balance and Health-related Quality of Life (HRQoL) in patients with stroke.

Data Sources: A literature search was done in Google Scholar, PEDro, Cochrane Library, Medline, Web of Science, and PubMed databases.

Eligibility Criteria: We performed a systematic review of randomized controlled trials published from June 2014 to January 2020, evaluating the effects of VRT on the balance and/or HRQoL in stroke. Fourteen eligible trials were analyzed, of which, 7 studies focused on balance and 7 on HRQoL.

Quality Appraisal: Methodological quality and risk of bias were assessed using the Cochrane tool.

Results: Most of the trials supported the effectiveness of VRT in improving balance and HRQoL. However, few trials reported similar improvements in HRQoL using VRT via Nintendo WiiTM games and conventional physiotherapy.

Conclusions: High to moderate evidence supports the effectiveness of VRT use in improving balance and HRQoL in stroke survivors.

Keywords: Balance, Health-related Quality of Life, Physiotherapy, Stroke, Rehabilitation, Virtual Reality Therapy

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1. Introduction

Stroke has been reported as one of the leading causes of disability and death globally [1]. In 2010, the worldwide prevalence of stroke was reported to be 33 million [2].

In recent years, Virtual Reality Therapy (VRT) has been introduced in the stroke rehabilitation program [3]. VRT has been popularized and recommended in stroke management [4-6]. Virtual Reality (VR) is defined as “an advanced type of human-computer interface that allows the user to interact and immersed in a computer-generated environment in a naturalistic design” [7]. VR-based rehabilitation has been proven to enhance goal-oriented training that significantly impacts patients’ adherence to exercise programs [8, 9]. Previous studies report that VR makes rehabilitation programs more attractive and engaging than traditional treatment programs. Hence it plays a great role in adhering to a physiotherapy treatment program for a prolonged duration [10].

A 2012 study reports that balance is essential to perform activities of daily living (ADL) [11]. Coordination and balancing impairments are the main complications of stroke patients [12]. The weakness of legs’ muscles profoundly affects walking and balance [13]. One study also reports balance to be an essential factor for gait recovery [14]. Another study found that the prefrontal cortex is the most vital brain part in controlling balance [15].

Research conducted by Lai SM et al. suggested that stroke status can significantly impact the ADLs and social participation of patients [16]. The patient’s independence in ADLs and improvement in health-related quality of life (HRQoL) are the essential goals of post-stroke physiotherapy.

Despite growing advances in the rehabilitation of stroke, yet a considerable portion of stroke survivors are living with significantly reduced HRQoL, especially in the domain of mobility and ADLs [17]. Previously conducted two systematic reviews and meta-analysis in 2016 and 2017 reported that VRT is effective in improving balance compared with conventional therapy in stroke [18, 19]. However, rigorous review regarding the effects of VRT on stroke is scarce. Therefore, this systematic review aims to critically evaluate the impact of VRT on balance and HRQoL in patients with stroke.

2. Materials and Methods

Study design

A systematic review was conducted on randomized controlled trials that assessed the effects of VRT on patients with stroke.

Review protocol

The review was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations [20].

Criteria for eligibility

Studies that met the following criteria were included: Study design must be a randomized controlled trial; clinically diagnosed hemorrhagic or ischemic stroke as the targeted population; trials evaluating balance or HRQoL as the outcome measure; trials analyzing/comparing the effects of VRT with an alternative intervention or no intervention; trials published from 2014 up to January 2020; and the article must be in English. Studies investigating the effects of rehabilitation other than the VR environment were excluded.

Sources of information

Six electronic databases that includes PEDro, Google Scholar, Cochrane Library, Web of Science, Medline, and PubMed were reviewed.

Search strategy

In January 2020, a systematic search was carried out using six different databases. Medical subject headings (MeSH) terms included “virtual reality therapy,” “gaming,” stroke,” “cerebrovascular accident,” “QOL,” “balance training,” “HRQoL,” “physiotherapy,” and “rehabilitation.” Titles and/or abstracts were reviewed, and those articles not meeting eligibility criteria were excluded. The remaining articles were studied in full to evaluate their suitability in consideration with the PRISMA guidelines.

Study selection

Initial screening was carried out based on the titles and/or abstracts by two reviewers (H.A.S. and F.H.). Then, the detailed evaluation of full text and analysis against the eligibility criteria was performed by two reviewers (D.K. and H.A.S.). The primary search sought a total of 252 studies; some studies were not freely accessible,
and others were irrelevant. Finally, 14 trials that met the eligibility criteria were reported in the review of which, seven studies evaluated the effect of VRT on balance and seven on HRQoL.

**Extraction of data**

The information like year of publication, location, sample size, intervention applied, frequency, duration of follow-up, outcome measures, and main findings were extracted from the included trials.

**Risk of bias**

The risk of bias was evaluated using the Cochrane tool [21]. It evaluates biases in various manners, which include random allocation, allocation concealment, blinding of participants and outcome assessment, incomplete outcome data, selective reporting, and other factors.

**3. Results**

**Selection of studies**

The initial screening identified 252 records in different databases. A total of 152 articles were excluded based on titles and/or abstracts, not meeting the inclusion criteria and duplication. Also, 25 trials were retrieved to review in full, of which 14 RCTs were analyzed in this review [22-35]. Figure 1 shows the PRISMA flow diagram of the selection strategy of the trials.

![Figure 1](image.png)

Figure 1. The selection process of studies

**Study characteristics:**

All 14 trials involved a total of 759 stroke patients and investigated the effects of VRT on balance and/or HRQoL in stroke patients. All trials were conducted from June 2014 to January 2020.

**Results of the studies related to the effects of VRT on balance in stroke**

The sample size of the seven studies related to the effects of VRT on balance in stroke was 234, with few trials reported sample size calculation. The follow-up duration of the trials ranged from 1 to 3 months. However, most studies used the Berg Balance Scale (BBS) and Timed Up and Go (TUG) tests as outcome measures [23-28] (Table 1).

A recent study conducted by Lisa et al. [22] reported that VRT with or without trunk movement shows similar improvement in sitting balance. Various trials reported significant improvement in the balance of stroke survivors by VRT using Jintronix rehabilitation, Motion Rehab AVE 3D, Canoe games, Virtual Reality Reflection Therapy (VRRT), and 3D virtual environment compared with the Conventional Physiotherapy Therapy (CPT) [23-27]. Also, a trial conducted in Canada by McEwen et al. [28] reported that VRT using IREX VR games (interactive rehabilitation exercise software) was significantly effective in improving both sitting and standing balance in stroke patients (Table 1).
Table 1. Summary of the trials related to the effects of VRT on balance

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Study design</th>
<th>Location</th>
<th>Sample size</th>
<th>Duration of follow-up</th>
<th>Outcome measure</th>
<th>Main findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lisa et al. [22]</td>
<td>2020</td>
<td>RCT</td>
<td>Canada</td>
<td>n=69, (EG=33 and CG=36)</td>
<td>1 Month</td>
<td>FIST and OSS</td>
<td>Significant improvement in BBS in EG as compared to CG.</td>
</tr>
<tr>
<td>Sheehy et al. [23]</td>
<td>2019</td>
<td>RCT</td>
<td>Canada</td>
<td>n=20, (EG=10 and CG=10)</td>
<td>6 weeks</td>
<td>BBS, TUG test and CB &amp; M</td>
<td>Significant improvement in BBS in EG as compared to CG.</td>
</tr>
<tr>
<td>Henriques et al. [24]</td>
<td>2019</td>
<td>RCT</td>
<td>Brazil</td>
<td>n=31, (EG=16 and CG=15)</td>
<td>3 Months</td>
<td>BBS</td>
<td>Significant improvement in BBS in EG as compared to CG.</td>
</tr>
<tr>
<td>Lee et al. [25]</td>
<td>2016</td>
<td>A pilot RCT</td>
<td>South Korea</td>
<td>n=10, (EG=5 and CG=5)</td>
<td>2 Months</td>
<td>BBS</td>
<td>BBS and TUG scores were statistically greater in the EG as compared to CG.</td>
</tr>
<tr>
<td>In et al. [26]</td>
<td>2016</td>
<td>RCT</td>
<td>South Korea</td>
<td>n=25, (EG=13 and CG=12)</td>
<td>1 Month</td>
<td>TUG</td>
<td>Considerable improvement in the balance of the VRT group was found.</td>
</tr>
<tr>
<td>Lloréns et al. [27]</td>
<td>2015</td>
<td>RCT</td>
<td>Spain</td>
<td>n=20, (EG=10 and CG=10)</td>
<td>3 Months</td>
<td>BBS, Tinetti POMA, and BBA</td>
<td>Greater improvement was reported in EG compared to CG.</td>
</tr>
<tr>
<td>McCwen et al. [28]</td>
<td>2014</td>
<td>RCT</td>
<td>Canada</td>
<td>n=59, (EG=30 and CG=29)</td>
<td>1 Month</td>
<td>TUG</td>
<td>Both groups reported improvement in balance.</td>
</tr>
</tbody>
</table>

Results of the studies related to the effects of VRT on HRQoL in stroke

The sample size of the seven studies related to the impact of VRT on HRQoL in stroke was 525. The follow-up duration of the studies ranged from one to six months. Trails reported that VRT using RAPEL Smart Board™, RAPEL Smart Glove™, and Gait Real-time Analysis Interactive Lab (GRAIL) significantly improved HRQoL compared to the CPT [29, 30, 33]. However, Zheng et al. found that the addition of repetitive transcranial magnetic stimulation (rTMS) together with VRT more significantly improved HRQoL compared to VRT alone [34]. Lee et al. reported similar improvement in QoL via VRT, either performed individualized or group-based [32]. Two studies showed homogeneous improvement in QoL by VRT via Nintendo Wii™ (NW) games and CPT [31, 34] (Table 2).

Risk of bias within Studies and quality appraisal:

All trials had a low risk of bias in random allocation. Only one study showed a low risk of bias in all the measures [34]. In the majority of the trials, a high risk of bias...
regarding allocation concealment was found [22, 24-26, 28, 31]. Nine trials reported a low risk of bias in blinding of participants [23, 27-34]. The risk of bias of some studies could not be determined from the method defined for other biases [25, 27, 30] (Table 3).
Most trials support the effectiveness of VRT in improving balance and HRQoL. However, few trials reported similar improvement using VRT via NWTM games and CPT in improving HRQoL. A study conducted by Brumels KA et al. reported that conventional balance training results with poor adherence and interest in a rehabilitation program would lead to poor recovery [36]. However, VRT, with its attractiveness and engagement, helps the patient to focus on the exercise and recover faster. This evidence is supported by various trials that reported a considerable improvement in the balance of stroke patients using VRT via Jintronix rehabilitation, Motion Rehab AVE 3D, Canoe games, VRRT, and 3D virtual environment compared with CPT [23-27]. Based on the efficacy of VRT, Pietrzak et al. recommended in their study that emphasis should be placed on its use in stroke rehab program [37].

Trials conducted by Adie K et al. and Da Silva et al. reported homogeneous improvement in QoL between...
VRT via NWTM games and CPT [31, 34]. However, these results are contradicted by Morone G et al. trial reporting that balance training performed via video game-based treatment, i.e., Wii Fit, in addition to the conventional therapy, was found to be useful for improving balance compared to CPT alone in patients affected by stroke [38].

Imam B et al. claimed that the beneficial effects of VRT in stroke patients could be the influence of multi-sensory involvement, i.e., visual and auditory feedback and the motivational aspect of the VR environment [39]. Another study supported this finding and stated that sensory feedback allows the central nervous system to control orientation and body position [40]. This finding contradicts an essential feature of exercises presented in neuro-rehab, i.e., continuous repetition facilitates speedy functional recovery [41].

The evidence remains of moderate quality as the risk of bias of most trials was unclear due to poor reporting style. Approximately 50% of the trials reported a high risk of bias in allocation concealment [22, 24-26, 28, 31]; likewise, the majority of the studies reported a high risk of bias regarding other issues [22, 23, 30-34].

The included trials reported considerable variation in the type of VRT intervention used, time, frequency, outcome measure, and setting. The duration of follow-up ranged from one to six months. Hence it is difficult to turn these preliminary findings into generalized recommendations regarding its efficacy. However, most studies support the effectiveness of VRT in improving balance and HRQoL in stroke and that this tool has the potential to motivate and facilitate feedback-rich rehabilitation. Furthermore, no trial reported adverse effects suggesting that the VRT is a safe treatment for stroke survivors.

In consideration to the conceptual framework of the International Classification of Functioning (ICF), Disability and Health, this review reveals that VRT plays an essential role in enhancing the activity limitation (balance) and participation restriction (HRQoL) of a critical health condition (stroke).

One of the strengths of this review is focusing on the use of RCTs (2014 to January 2020) with valid and reliable instruments to measure outcomes and analyze the results.

Although the proposed review is of tremendous clinical significance in the domain of neuro-rehabilitation and, particularly to stroke, some limitations should be addressed. A considerable variety of VR interventions were categorized under the same term (VRT). Furthermore, acute, subacute, and chronic strokes were not separately evaluated. The sample size and methodological quality of some studies were found inadequate.

Further high-quality studies with larger sample sizes are needed to clearly understand which type of VRT is most effective, and what will be the optimal time and intensity to achieve a better outcome in different stages of stroke.

5. Conclusion

High to moderate evidence supports the effectiveness of VRT in improving balance and HRQoL in stroke survivors. However, due to insufficient evidence, a robust and reliable conclusion cannot be drawn. The finding of this review is essential in clinical practice and serves as a preliminary step in providing constructive criticism to upgrade the methodology of future studies.

Ethical Considerations

Compliance with ethical guidelines

Ethical principles were considered in all reported trials. Furthermore, informed consent was taken, and confidentiality was maintained.

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Authors contributions

Conceptualization and Writing original draft: Hajra Ameer Shaikh substantially; Data collection: Fouzia Hussain; Writing-review & Editing: Darshan Kumar.

Conflict of interest

The authors declared no conflicting interests.

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