The Impact of Immersive and Non-Immersive Virtual Reality Trends in Sensorimotor Recovery of Post-Stroke Patients-A Meta-Analysis

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Abstract: Virtual Reality (VR) is an approach in stroke rehabilitation with ever-improving technological advancement for targeted motor rehabilitation by providing a user interface in a simulated environment with proprioceptive and visual feedback. This meta-analysis intended to evaluate the impact of immersive and non-immersive VR-based interventions compared to conventional rehabilitation in sensorimotor recovery following stroke. Randomized Controlled Trials based on the impact of VR, either immersive or non-immersive type in comparison to conventional rehabilitation on post-stroke patients (≥18 years) sensorimotor recovery were searched on six databases including Google Scholar, PEDro, MEDLINE, Cochrane Library, EMBASE, and Web of Science from August to November 2020. A total of 17 randomized controlled trials on VR based intervention showed significant improvement in sensorimotor recovery following a stroke in overall FMA outcomes in comparison to the control group with pool effects in terms of SMD in a random effect model showed an impact of 0.498 at 95% CI ($p<0.001$) depicts a moderate effect size. An immersive and non-immersive emerging VR trend appears to be a promising therapeutic tool in sensorimotor recovery following stroke.

Keywords: Virtual Reality, Technology, Stroke, Sensorimotor Feedback, Environmental Impact, Health-related Quality of Life.

INTRODUCTION

Stroke is the second leading global cause of mortality, counting for 6.5 million deaths per annum [1-2]. Another 25.7 million people worldwide have a neurological disability caused by the disease, making it the third leading cause of disability after heart diseases and cancer [3]. The global prevalence of stroke increases with an estimated prevalence of 33 million per year, affecting 1 out of 6 individuals during their lifetime [4]. The epidemiology of stroke is highest in Asia with an increasing incidence of 25% from 1990 to 2013 in individuals aged between 20 to 64 years with the world's highest rate of stroke per capita reported in Pakistan with an incidence of 250 per 100,000 stroke individuals from the year 2000-2017 [5]. This growing burden is a significant public health concern due to the increase in stroke incidence and Disability-Adjusted Life Years (DALYs) because of the demographic transitions of the population, particularly in developing countries [4]. Therefore, appropriate and timely stroke intervention is required to save healthcare costs and reduce the disease burden.

Motor Relearning such as, Neurodevelopmental Techniques (NDT), Constraint-Induced Movement Therapy (CIMT), Electrical Stimulation, Adaptive or Remedial procedures that aimed to restore the motor function, cognition and activities of daily living [5].

Mentioned strategies have been successful in varied contexts. However, due to heterogeneity of cognitive-motor deficits, the recovery outcomes in this area are still unclear [5]. The physical therapy management of stroke patients in the acute phase is intended to prevent potential complications that may predict favorable recovery within six months of stroke [6]. Several studies have reported the importance of stroke rehabilitation in the sub-acute phase with more affected functional recovery than chronic stroke patients demonstrated by functional recovery plateau [5, 6]. Therefore, many researchers advocate that early intervention is required to reduce the residual disability to achieve optimal active recovery in stroke patients.

On the contrary, some studies reported minor improvements in patients' functional outcomes due to prolonged treatment sessions and labor-intensive therapies. Over the past few decades, stroke rehabilitation has revolutionized technological advancements with new rehabilitation approaches, including robotic therapies, mirror therapy, virtual reality, and drug augmentation, highlighting promising rehabilitation outcomes for stroke recovery [7].

According to a recent Cochrane review, Virtual Reality (VR) is an approach in stroke rehabilitation with ever-improving technological advancement for targeted

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motor-rehabilitation by providing user interface in a simulated environment with proprioceptive and visual feedback [7, 8]. Studies have reported the effectiveness of VR intervention in cognitive abilities, but it has been simultaneously effective in improving other domains such as attention and coordination with motor retraining [8]. Therefore, this meta-analysis is intended to evaluate the impact of immersive and non-immersive VR-based interventions compared to conventional rehabilitation in sensorimotor recovery following stroke.

MATERIAL AND METHODS

This study was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) recommendations.

Electronic Databases and Searching Strategies

Studies based on the impact of VR, either immersive or non-immersive type in comparison to conventional rehabilitation on post-stroke sensorimotor recovery, were searched on six databases including, Google Scholar, PEDro, MEDLINE, Cochrane Library, EMBASE, and Web of Science from August to November 2020, considering MeSH terms such as "Stroke," "Post-stroke," "Stroke Rehabilitation," “Virtual Reality” and “Sensorimotor Feedback” etc.

Criteria for Eligible Studies and Participants

Randomized Controlled Trials based on VR based intervention versus control/conventional or dose-matched conventional therapy, used immersive and non-immersive approaches, i.e., commercial games, VR systems, or hybrid approaches on clinically diagnose post-stroke patients (Acute, Sub-acute, and Chronic phase) aged $\geq$18 years, published in the English language during the year 2010 to 2020 were selected.

Trials without a control group or a condition and participants who had previous stroke and comorbidities were excluded. Moreover, participants were not filtered in terms of types of stroke (ischemic/hemorrhagic), site of lesion (cortical/sub-cortical), or level of sensorimotor deficit severity (mild, moderate, and severe). Furthermore, unavailable full-text articles and un-preferred language publications are not considered.

Selection of Outcome Measure

The number of outcome measures for sensorimotor feedback from each comparable study was extracted accordingly; thus most frequently occurring outcome measure ‘FMA’ was selected. Fugl-Meyer Assessment (FMA) [9] was used to assess post-stroke sensorimotor function and recovery of hemiplegic patients. The scale comprises 5 domains, including motor function, sensory function, balance, joint ROM, and joint pain, in which the items will be scored on a 3-point ordinal scale with maximum scoring of 66 points.

Data Extraction and Analysis

The data was extracted in particular to a year of publication, study design, target population, type of VR and intervention, experimental and control group.

Risk of Bias

The risk of bias was evaluated using the Cochrane tool to assess the risk of bias [10] in random allocation, allocation concealment, blinding of participants and outcome assessment, incomplete outcome data, selective reporting, and other biases.

Quantitative Analysis

The quantitative analysis was determined using MedCalc Statistical Software (Version 18.11.3). Assumption of heterogeneity and SMD (Standardized Mean Difference) between groups with pooled S.D (Standard Deviation) was analyzed using a random effect model at 95% confidence interval. While using Cohen's rule of thumb categories, the effect size was outlined as small = 0.2 to 0.5; moderate=0.5 to 0.8 and large = >0.8, respectively, whereas the level of heterogeneity amid studies computed using I^2 statistics though the significant value was indicated on $p<0.05$.

RESULTS

The Flow of Studies through Review

A total number of 825 records of stroke patients were included after searching potentially relevant published articles from six electronic databases. The search strategy provided 2,080 original articles that were further evaluated upon their title and content. In contrast, full-text relevant articles were sorted and selected after removing 786 duplications and 253unavailable full-text and un-preferred language publications. After the full-text screening, only 17 randomized controlled trials met the inclusion criteria targeted VR-based interventions on sensorimotor recovery following a stroke compared to conventional rehabilitation, as shown in Table **1** while the flow of studies is illustrated in Figure **1**.

Table 1: Represents Characteristics Features of the Included Studies

Author' Year	Sample Size	Target Population	Study Design	VR Type	Intervention	
					Intervention Group	**Control Group**
Oh *et al*. 2019 [11]	31	Post-stroke patients in chronic phase aged 20-85 years	Single-blind, Randomized Trial	Immersive	VR combined with real instrument training, 30 mins/day, 3 days/week for 6 weeks.	Conventional Occupational Therapy,30 mins/day, 3 days/week for 6 weeks
Asfar *et al*. 2018 [12]	35	Post-stroke patients in Sub-acute phase aged ≥ 60 years	Randomized Controlled Trial	Immersive	VR combined with Conventional Rehabilitation, 90 mins/day, 5 days/week for 4 weeks.	Conventional Rehabilitation Program, 60 mins/day, 5 days/week for 4 weeks
Ballester *et al*. 2016 [13]	18	Post-stroke patients in chronic phase aged 25-75 years	Randomized Double-Blind Study	Immersive	VR-based training on goal-oriented movement amplification, 30 mins/day, 5 days/week for 6 weeks.	VR found activity without amplification, 30 mins/day, 5 days/week for 6 weeks.
Lee *et al*. 2016 [14]	10	Post-stroke patients in Sub-acute phase aged ≥ 60 years	Randomized Controlled, Pilot Study	Non-Immersive	Conventional rehabilitation, with additional VR based training programs, 30 mins/day, 3 days/week for 4 weeks	Traditional rehabilitation consisted of Physical and Occupational Therapy for 30 mins, twice a day, 5 days/ week with FES for 15 mins/day, 5 days/week, for 4 weeks.
Park and Park. 2016 [15]	30	Post-stroke patients in chronic phase aged 18-80 years	Randomized Controlled, Pilot Study	Non-Immersive	VR based movement therapy, 20 sessions of 30 mins, 5 days/week for 4 weeks with 5 mins of relaxation	VR based movement therapy, 20 sessions of 30 mins, 5 days/week for 4 weeks
Shin *et al*. 2016 [16]	46	Post-stroke patients aged ≥ 18 years	Single-Blinded Randomized Controlled Trial	Immersive	Smart Glove, 20 sessions of 30 mins, for 4 weeks	Conventional rehabilitation, 20 sessions of 30 mins, for 4 weeks
Kong *et al*. 2016 [17]	64	Post-stroke patients in the Sub-acute phase aged 21-80 years	Randomized Controlled Study	Non-Immersive	VR based commercial gaming for 60 mins, 4 times/week for 3 weeks	Conventional Therapy for 60 mins, 4 times/week for 3 weeks
Kiper *et al*. 2014 [18]	44	Post-stroke patients in chronic phase aged ≥ 60 years	Single-Blind Randomized Controlled Trial	Immersive	Reinforced Feedback in Virtual Environments for 2 hours, 5 days/week for 4 weeks	Traditional rehabilitation for 2 hours, 5 days/week for 4 weeks
Thielbar *et al*. 2014 [19]	14	Post-stroke patients in chronic phase aged ≥ 40 years	Randomized Controlled Trial	Immersive	Mechatronic VR with an actuated virtual keypad and Occupational Therapy, 18 one-hour training sessions, 3 times/week for 6 weeks	Occupational Therapy, 18 one-hour training sessions, 3 times/week for 6 weeks
Shin *et al*. 2014 [20]	16	Acute and Sub-Acute stroke patients aged ≥ 40 years	Randomized Controlled Trial	Immersive	Task-specific Interactive Game-Based VR for 20 mins with 10 sessions of Occupational Therapy for 2 weeks	Conventional Occupational Therapy, 10 sessions for 2 weeks
Viana *et al*. 2014 [21]	20	Post-stroke patients in chronic phase aged ≥ 50 years	Pilot Double-Blind Randomized Controlled Trial	Non-Immersive	One-Hour VR with Transcranial Direct Current Stimulation for 13 mins, 15 sessions for 5 weeks	One-Hour VR with Sham Transcranial Direct Current Stimulation for 13 mins, 15 sessions for 5 weeks

(Table 1). Continued.

Author' Year	Sample Size	Target Population	Study Design	VR Type	Intervention	
					Intervention Group	Control Group
Choi *et al*. 2014 [22]	20	Sub-acute stroke patients aged ≥ 60 years	Randomized, Single-Blind Study	Non-Immersive	Combined Conventional Therapy with Commercial gaming-based VR therapy using Wii for 30 mins, 5 times/week for 4 weeks	Conventional Occupational Therapy for 30 mins, 5 times/week for 4 weeks
Turolla *et al*. 2013 [23]	376	Acute and Sub-Acute stroke patients aged ≥ 60 years	Prospective Controlled Trial	Immersive	Combine VR with Upper Limb Conventional Therapy, 2 hours, 5 days/week for 4 weeks	Upper Limb Conventional Therapy, 2 hours, 5 days/week for 4 weeks
Levin *et al*. 2012 [24]	12	Post-stroke patients in chronic phase aged 33-80 years	Randomized Controlled Trial	Immersive	Video-capture VR therapy, 9 sessions of 45 mins for 3 weeks	Conventional Therapy,9 sessions of 45 mins for 3 weeks
Kwon *et al*. 2012 [25]	26	Post-stroke patients in the sub-acute phase aged ≥40 years	Double-blind, Randomized Controlled Trial	Immersive	VR in combination with Conventional Therapy, for 1 Hour 20 mins, 5 times/week for 4 weeks	Conventional Therapy, for 70 mins, 5 times/week for 4 weeks
da Silva Cameirão *et al*. 2011 [26]	16	Post-stroke patients in the sub-acute phase aged ≥50 years	Randomized Controlled Pilot Study	Immersive	VR in combination with Conventional Therapy, for 20 mins, 3 times/week for 12 weeks	Intense Occupational Therapy or non-specific interactive games for 12 weeks
Prion *et al*. 2010 [27]	47	Post-stroke patients in chronic phase aged ≥50 years	Pilot Randomized Controlled Study	Immersive	Reinforced Feedback in Virtual Environments for 1 hour, 5 days/week for 4 weeks	Conventional Therapy for 1 hour, 5 days/week for 4 weeks

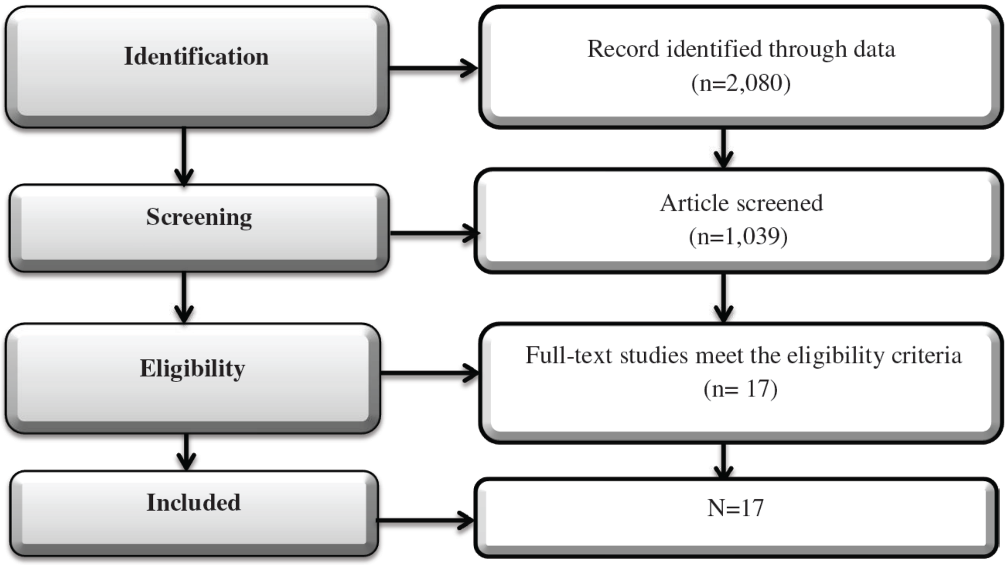

Figure 1: Represents the flow of studies following the PRISMA statement.

Characteristics of Study Participants

The included studies comprised 825 participants, out of which 496 were randomized into the experimental group to receive VR intervention alone or in combination with Conventional Therapy, if applicable whereas, 329 were allocated to the control group to receive Conventional Rehabilitation. Moreover, 8

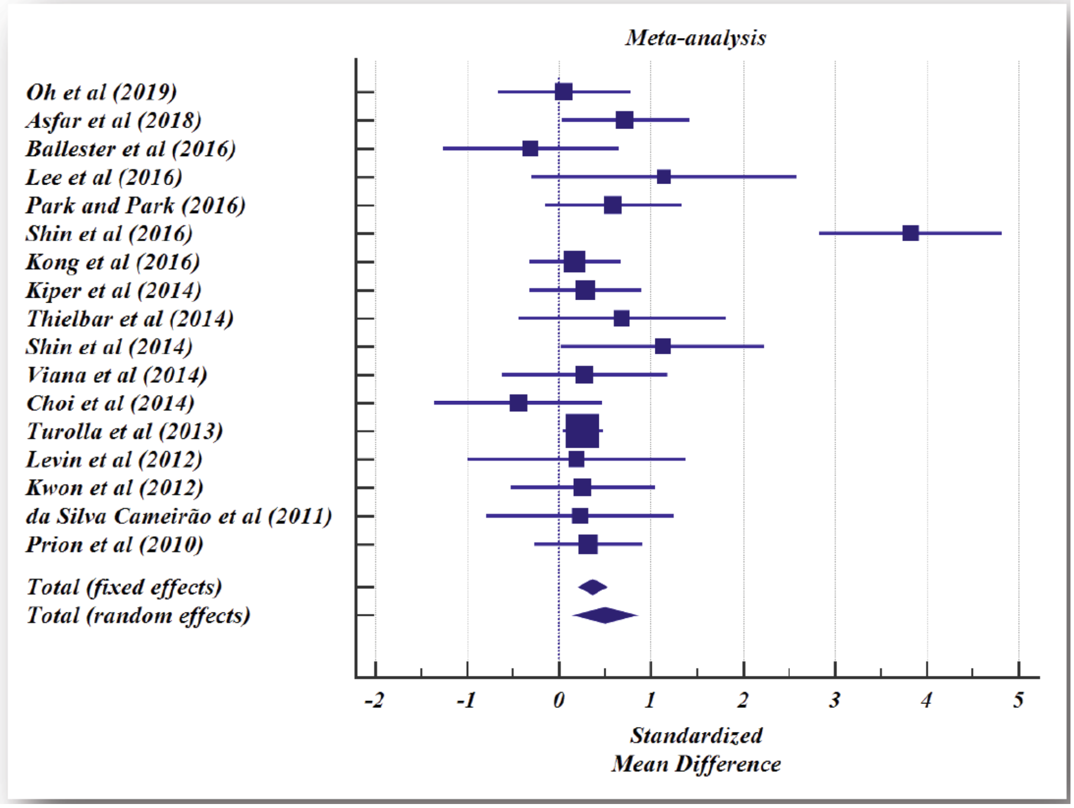

Figure 2: Represents studies that significantly improve sensorimotor recovery following a stroke in overall FMA outcomes.

studies recruited participants in the sub-acute phase [12,14,17,20,22,23,25,26], 8 studies in the chronic phase [11,13,15,18,19,21,24,27] while 1 study didn't report the phase of the stroke [16].

FMA Meta-Analysis

The findings of 17 randomized controlled trials revealed that the VR-based intervention showed significant improvement in sensorimotor recovery following a stroke in overall FMA outcomes compared to the control group. The pool effects of VR intervention in terms of SMD in a random effect model showed an impact of 0.498, which according to a Cohen rule of thumb, depicts a moderate effect of VR in improving sensorimotor function following stroke as shown in Table **1**. Furthermore, the result was also intrigued by the forest plot to represent the pool effects in the random effect model at 95% of C.I as shown in Figure **2**.

Test for Heterogeneity

Estimation of Q and I^2 tests were utilized to identify the statistical heterogeneity. Q=63.1864 and I^2= 74.68% indicated a level of inconsistency on a random effect model within 95% of C.I. (59.30 to 84.24) depicted in Table **2**.

Immersive vs. Non-Immersive

A total of 5 out of 17 studies were based on non-immersive approaches comprised of Nintendo Wii games [14,15,17,21,22]. In contrast, the remaining studies were based on immersive VR technologies, out of which 7 studies used VR Systems such as Xbox Kinect [12], Rehabilitation Gaming System [13,26], RAPAEL Smart Glove^{TM} System (16), Virtual Reality Rehabilitation System [18,23] and IREX VR System [25], 1 study had Real Instrument (Joystim) [11]. In comparison, 3 studies used other VR interventions, including Actuated Virtual Keypad [19], Gesture Xtreme® [24], and Polhemus 3Space Fastrak [27], as depicted in Table **3**.

Quality Appraisal and Risk of Bias

The risk of bias was exempted upon the author's judgment on the Cochrane tool for assessing the risk of bias in the following domains, as shown in Table **4**, Figure **3**.

Random Sequence Generation

The randomization sequence was generated for the entire seventeen studies' which showed a low risk of bias [11-27].

Table 2: SMD on a Random Effect Model within 95% of CI and Statistical Heterogeneity

Study	N1	N2	Total	SMD	SE	95% CI	t	P	Weight (%)	
									Fixed	Random
Oh *et al*. (2019)	17	14	31	0.0525	0.352	-0.667 to 0.771			4.33	6.37
Asfar *et al*. (2018)	19	16	35	0.719	0.342	0.0223 to 1.416			4.56	6.47
Ballester *et al*. (2016)	9	9	18	-0.308	0.452	-1.265 to 0.650			2.62	5.39
Lee *et al*. (2016)	5	5	10	1.142	0.625	-0.300 to 2.584			1.37	3.97
Park and Park (2016)	15	15	30	0.584	0.363	-0.160 to 1.328			4.06	6.26
Shin *et al*. (2016)	24	22	46	3.828	0.493	2.833 to 4.822			2.20	5.01
Kong *et al*. (2016)	31	33	64	0.172	0.248	-0.323 to 0.667			8.73	7.42
Kiper *et al*. (2014)	23	21	44	0.285	0.298	-0.317 to 0.886			6.03	6.92
Thielbar *et al*. (2014)	7	7	14	0.683	0.517	-0.443 to 1.808			2.00	4.81
Shin *et al*. (2014)	9	7	16	1.128	0.516	0.0206 to 2.236			2.01	4.81
Viana *et al*. (2014)	10	10	20	0.274	0.430	-0.630 to 1.179			2.89	5.59
Choi *et al*. (2014)	10	10	20	-0.441	0.434	-1.353 to 0.471			2.84	5.56
Turolla *et al*. (2013)	263	113	376	0.258	0.113	0.0365 to 0.480			42.16	8.52
Levin *et al*. (2012)	6	6	12	0.188	0.534	-1.002 to 1.378			1.88	4.66
Kwon *et al*. (2012)	13	13	26	0.257	0.381	-0.530 to 1.044			3.68	6.07
da Silva Cameirão *et al* (2011)	8	8	16	0.225	0.474	-0.792 to 1.243			2.38	5.18
Prion *et al*. (2010)	27	20	47	0.317	0.292	-0.271 to 0.905			6.28	6.98
Total (fixed effects)	496	329	825	0.361	0.0731	0.218 to 0.505	4.940	<0.001*	100.00	100.00
Total (random effects)	496	329	825	0.498	0.168	0.168 to 0.827	2.968	0.003	100.00	100.00
Q	63.1864									
Significance level	P < 0.0001*									
I^2 (inconsistency)	74.68%									
95% CI for I^2	59.30 to 84.24									

*Significant p<0.05.

Allocation Concealment

Similarly, the concealed allocation was considered for all randomized controlled trials represented a low risk of bias [11-27].

Blinding of Participants and Personnel

Only eleven studies [11,13,16-18,20-22,24,25,27] considered the participants and personnel blinding, whereas three studies [14,15,19] showed unknown blinding approach while high risk of bias was revealed in three studies [12,23,26].

Blinding of Outcome Assessment

Only two studies [12,18] showed high risk of bias while remaining represented low risk [11,13-17, 19-27].

Incomplete Outcome Data

Seven studies [12,13,15,22,23,25,26] showed high risk of bias while remaining represented low risk [11,14,16-21,24,27].

Selective Reporting

The low risk of bias was demonstrated among all the seventeen studies [11-27].

DISCUSSION

The studies included in this meta-analysis determined the impact of immersive and non-immersive VR trends in sensorimotor recovery following stroke. The robust evidence originated from the included trials that VR-based interventions significantly improve the overall FMA outcomes

Table 3: Frequency of VR Intervention

Types of Intervention	Frequency (%)
VR Based System	
Xbox Kinect System	1 (5.8%)
Rehabilitation Gaming System	2 (11.7%)
RAPAEL Smart Glove™ System	1 (5.8%)
Virtual Reality Rehabilitation System	2 (11.7%)
IREX VR System	1 (5.8%)
VR Based Games	
Real Instrument (Joystim)	1 (5.8%)
Nintendo Wii	5 (29.4%)
Others	
Actuated Virtual Keypad	1 (5.8%)
Gesture Xtreme®	1 (5.8%)
Polhemus 3Space Fastrak	1 (5.8%)

Table 4: Cochrane Collaboration's Tool for Assessing Risk of Bias of Included Studies

Studies	Random Allocation	Allocation Concealment	Participants Blinding	Outcome Assessment Blinding	Incomplete Outcome Data	Selective Reporting
Oh *et al*. 2019 [11]	+	+	+	+	+	+
Asfar *et al*. 2018 [12]	+	+	-	-	-	+
Ballester *et al*. 2016 [13]	+	+	+	+	-	+
Lee *et al*. 2016 [14]	+	+	?	+	+	+
Park and Park. 2016 [15]	+	+	?	+	-	+
Shin *et al*. 2016 [16]	+	+	+	+	+	+
Kong *et al*. 2016 [17]	+	+	+	+	+	+
Kiper *et al*. 2014 [18]	+	+	+	-	+	+
Thielbar *et al*. 2014 [19]	+	+	?	+	+	+
Shin *et al*. 2014 [20]	+	+	+	+	+	+
Viana *et al*. 2014 [21]	+	+	+	+	+	+
Choi *et al*. 2014 [22]	+	+	+	+	-	+
Turolla *et al*. 2013 [23]	+	+	-	+	-	+
Levin *et al*. 2012 [24]	+	+	+	+	+	+
Kwon *et al*. 2012 [25]	+	+	+	+	-	+
da Silva Cameirão *et al*. 2011 [26]	+	+	-	+	-	+
Prion *et al*. 2010 [27]	+	+	+	+	+	+

−, indicates a high risk of bias.
+, exhibits a low risk of bias.
? suggests that the defined methodology cannot ensure the risk of bias Higgins *et al*. [10].

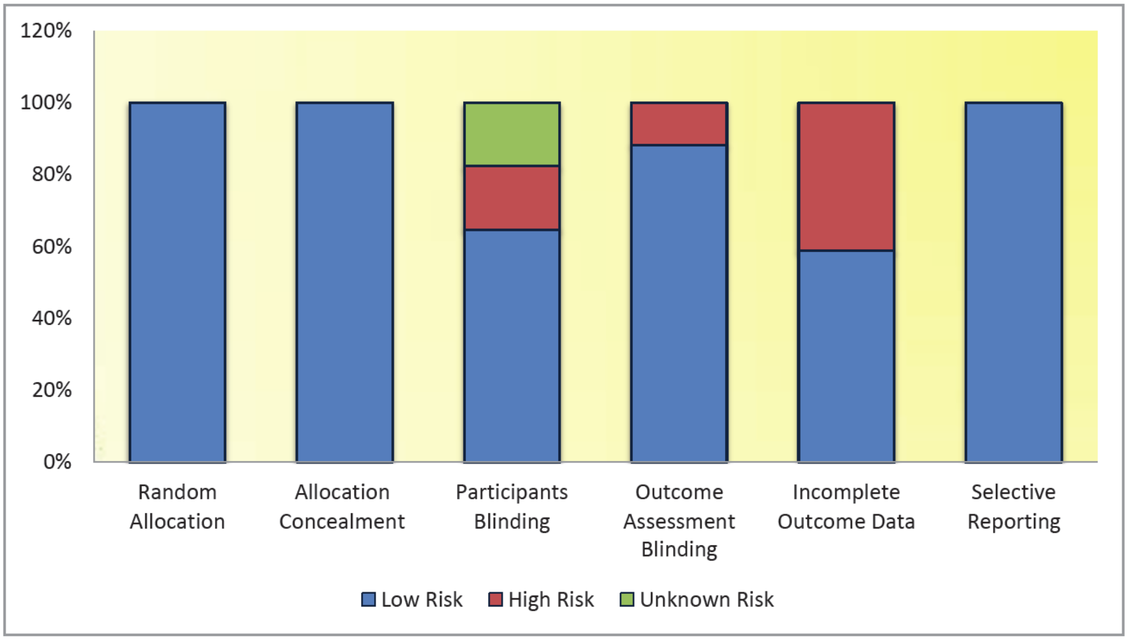

Figure 3: Author's judgment on Cochran's Risk of Bias Tool.

compared to the control group. The results of this review are similar to the findings of previous studies [27-28] that reported the pool effect of VR groups in FMA scores to that in the control group with statistical significance.

The majority of studies [12,14,22,23,25,26] were based on VR intervention combined with conventional physiotherapy compared to a conventional therapy program for 4 weeks that lead to significant sensorimotor recovery. VR combined with real instrument training [11] was also found to be effective in promoting sensorimotor recovery, thus proved to be an innovative translational neurorehabilitation approach following stroke. Consecutively, commercial games such as Nintendo Wii were frequently used as a non-immersive VR approach due to low-cost and easy implementation to improve motor function, balance, and trunk control in stroke patients [14,15,17,21,22]. On the contrary, Nintendo Wii gaming [17] was ineffective in upper limb motor recovery compared to the control group. At the same time, game-based VR [15,22] alone was beneficial in significant motor recovery. Similarly, Kinect-based gaming systems [12] with conventional therapy have supplementary benefits in post-stroke recovery; however, follow-up periods and larger sample sizes are required to determine the optimal duration and dose of the gaming interventions. Although diverse, immersive VR trends based on VR systems, based on hybrid, Reinforced environment, and Video-capture were observed to be used in recent years due to their patient-centered and repetitive training leads to better functional outcomes. In particular, Rehab Master [20] was found to be a feasible and safer approach to enhance sensorimotor function. It was also evident that reinforced VR environment [13,18,27] has significantly improved motor performance and functional activities indicated substantial evidence regarding arm-use training, enhanced function, and decreased spasticity, thereby exhibiting better health outcomes [21]. Moreover, a non-task-specific modality with VR platforms such as Actuated Virtual Keyboard [19] that comprises actively assisted individuation is proven to be a valuable clinical tool to enhance sensorimotor recovery. Also, Rehab Gaming System was found to be a promising tool in Neurorehabilitation [26]. The number of researches [20,23-25] suggested that VR-based rehabilitation combined with standard occupational therapy might be a more practical approach in dose-matched conventional medicine to improve motor function and health-related quality of life, thereby serving a modest advantage in the restoration of sensorimotor deficits. Consequently, post-stroke Neurorehabilitation is a substantial component in motor relearning aimed at the recovery of cognitive-motor outcomes to reduce patient dependence on daily living activities. However, in recent decades, VR-based intervention has proven to be a novel therapeutic approach for modest benefits compared to conventional rehabilitation.

Several limitations have been explored during the quantitative analysis of the VR-based interventions in the recovery of sensorimotor function, including the diversity of stroke population about ischemic or hemorrhagic stroke with the lesion's locality level of deficit severity and duration of the intervention. Furthermore, various control group therapies were not considered that may lead to variation in comparing VR with the control group. In addition, several studies didn't truly control the VR interventions in terms of intensity, frequency, level of task difficulty, and specificity. Further, older trials were included in the study to evaluate the rapid advancement in VR technology, leading to selection bias.

CONCLUSION

The review provided robust evidence that emerging immersive and non-immersive VR trends showed significant improvement in sensorimotor recovery following a stroke in overall FMA outcomes in comparison to the control group in the either acute, sub-acute, and chronic phase of stroke having a moderate effect size of 0.498, according to Cohen rule of thumb at 95% CI ($p<0.001$).

DECLARATION OF INTEREST

All authors have affirmed no potential conflicts of interest.

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AUTHOR’S CONTRIBUTION

JR: Concept, Design, and Writing.

SIF, AK, BAH: Supervision and critical review.

BH: Interpretation of data and critical revision.

ABBREVIATIONS

CIMT = Constraint-induced Movement Therapy

DALYs = Disability-Adjusted Life Years

EMBASE = Excerpta Medica dataBASE

FMA = Fugl-Meyer Motor Assessment

MEDLINE = Medical Literature Analysis and Retrieval System Online

NDT = Neurodevelopmental Techniques

PEDro = Physiotherapy Evidence Database

PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analysis

S.D = Standard Deviation

SMD = Standardized Mean Difference

VR = Virtual Reality

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