KnE Life Sciences

ICHT 2019
Selection and Peer-review under the responsibility of the ICHT Conference Committee
Volume 2019

Knowledge E
enriching | engaging | empowering

Conference Paper

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

Dita Hanna Febriani and Siwi Ikaristi Maria Theresia

Panti Rapih School of Health Science Yogyakarta

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 supportthe 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.

Corresponding Author:
Dita Hanna Febriani
dhitahanna@gmail.com

Received: 22 September 2019
Accepted: 4 October 2019
Published: 10 October 2019

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICHT 2019 Conference Committee.

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 reducedmobility 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 thelong-term rehabilitation process, the training method shouldbe functional and effective and should not be monotonous;rather, it should encourage patients'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 realityindicates a type of interactive simulation using computer hardware and software, in which users can have close-to-realityexperiences [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

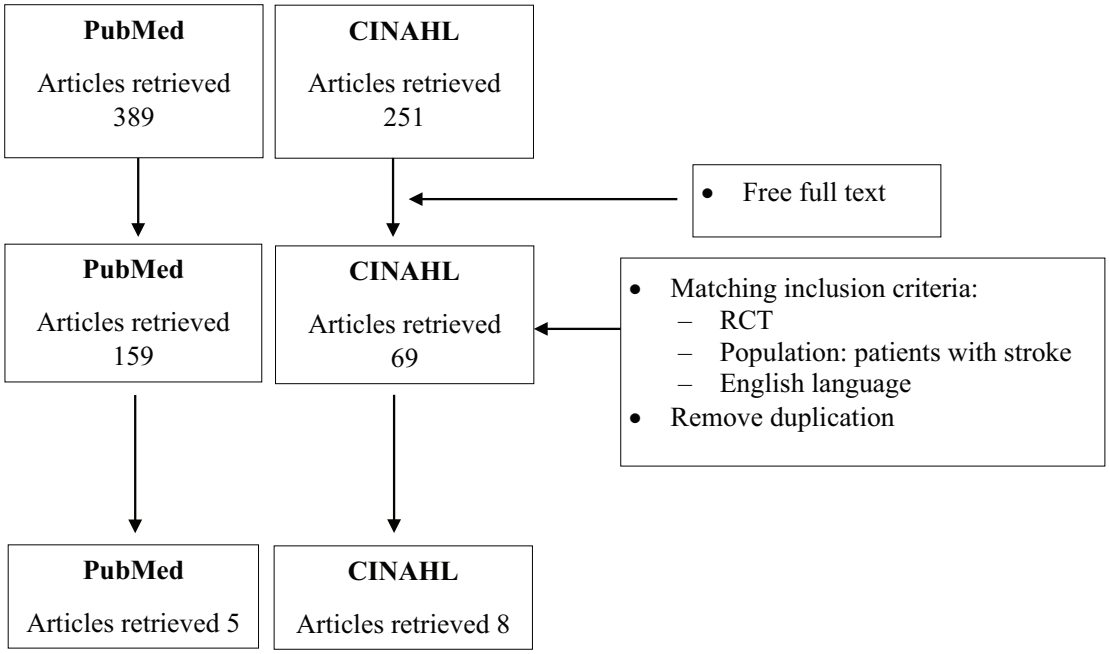

Figure 1: Flow chart of search strategy and result.

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.

No	Title/ Year of Publication	Author	Participants	VR Intervention	Outcome Measurement	Results
1	The efficacy of interactive, motion capture-based rehabilitation on functional outcomes in an inpatient stroke population: a randomized controlled trial / 2018	John C., Emelyn J., Amy R., Kylie I., Anna M T., Michele L C., Stuart T S., Kiran DK A., & Marie-Louise B.	Seventy three patients with infarct and hemorrhagic stroke who has decreased mobility.	iMCR (interactive motion capture-based rehabilitation) technology software (Jintronix ^{TM})	MMA for upper arm function	The participants improved limb function and time up and go (all $p <$ 0.04), upper in standing, sitting balance

No	Title/ Year of Publication	Author	Participants	VR Intervention	Outcome Measurement	Results
2	A low cost Kinect-based virtual rehabilitation system for inpatient rehabilitation of the upper limb in patients with subacute stroke/ 2018	Won-Seok K., Sungmin C., Seo H P., Ji-Yung L., SuYeon K., & Nam-Jong P	23 patients with subacute stroke. The participant were divided into 2 groups: 11 participants to sham group and 12 participants to real group	Kinect-based VR system and Rehacom	FMA, Brunnstrom stage for arm and hand, BBT	Upper limbshowed significant improvement across times (P<0.001)
3	Effect of virtual reality games on strike patients' balance, gait, depression and the interpersonal relationships/ 2015	Gui B S., & Eun C P.	The participants were 40 patients with chronic strokedivided into 2 group Virtual Reality Group (VRG) and Ergometer Training Group (RTG)	Xbox Kinect	LOS, TUG	The VRG showed more significant increase in balance, gait abilities, interpersonal relationship and reduce depression (p<0.05)
4	Effect of a virtual reality video game exercise program on upper extremity function and daily living activities in stroke patients/ 2018	Ju-Hong K.	The participants were 24 hemiplegia patients with chronic stroke.	Wii Sport and Wii Fit software produced by Nintendo	FMA and MFT	The experimental group participants' daily living activities improved after training (p<0.001) The upper extremity function between the group was not significantly different (p<0.05)
5	Effect of virtual reality-based rehabilitation on distal upper extremity function and health-related quality of life: a single-blinded, randomized control trial/ 2016	Joo-Ho S., Mi-Young K., Ji-Yeong I., Yu-Jin J., Suypung K., Soobin L., Beomjoo S., & Younggeun C.	The participant were 46 patients with upper extremity deficit by stroke	RAPAEL Smart Glove ^{TW} (Neofect, Yong-in, Korea)	FMA, JTT, PPT, SIS.	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

No	Title/ Year of Publication	Author	Participants	VR Intervention	Outcome Measurement	Results
6	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	Corina S A., Kynan E., Zorica S., Irene T., Sandra S., Isabelle L., Ludwig S., Michael A M., Miura H., Martin L V., & Daniel K.	The participants were 54 patients post stroke	You Grabber (now Bi-Manu-Trainer)	BBT, CAHAI, SIS	The experimental group showed higher improvement on the hand function, activities daily living and mobility index than conventional group by SIS ($p=0.057$)
7	Efficacy and safety of non-immersive virtual reality exercising in stroke rehabilitation (EVREST): a randomized, multicenter, single-blind, controlled trial/ 2016	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., & Mark B.	The participants were 121 patients with stroke	Nintendo Wii (Nintendo Co., Ltd, Kyoto, Japan)	WMFT	There was no significantly benefit between VR and recreational rehabilitation ($p=0.93$), even though the VR is safe.
8	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	Park, J. H., & Park, J. H	Thirty subject with chronic stroke recruited. Each experimental and control group had 15 subjects.	Wii Sports and Wii Sports Resort games (the bowling, table tennis, and canoeing games) by Nintendo, Kyoto, Japan	FMA, BBT, MAL-QOM	Game-based virtual reality movement effective for functional recovery upper extremity ($p < 0.05$). The effect will increase when it combined with mental practice.
9	The effect of virtual reality-based eccentric training on lower extremity muscle activation and balance in stroke patients/ 2016	Park, S. K., Yang, D. J., Uhm, Y. H., Heo, J. W., & Kim, J. H	Thirty chronic stroke patients (15 patients using a slow velocity eccentric training and 15 patients using a fast velocity eccentric training)	An Eccentron (BTE Technologies Inc., Hanover, MD, USA)	EMG, BioRescue	Lower extremity muscle and balance ability of the subjects improved after 8-weeks intervention with eccentric training using a slow velocity ($p < 0.05$).

No	Title/ Year of Publication	Author	Participants	VR Intervention	Outcome Measurement	Results
10	Effect of virtual reality training using Nintendo Wii and treadmill walking exercise on balance and walking for stroke patients/ 2016	Bang, Y. S., Son, K. H., & Kim, H. J	Forty stroke patients (20 in virtual reality training and 20 in treadmill exercise)	Wii-fit by Nintendo, Japan	Pedoscan, Smart Step	There were a significant differences in balance and walking after completing virtual reality training ($p < 0.05$ and ($p < 0.01$).
11	Effect of virtual reality-based training and task oriented training on balance performance in stroke patients/ 2015	Lee, H. Y., Kim, Y. L., & Lee, S. M.	Twenty four stroke patients randomly divided into virtual reality training group (n=12) and task oriented group (n=12)	Wii, Wii Balance Board and Wii Fit plus	FRT	Virtual reality training improve dynamic balance in patients with stroke ($p < 0.0001$).
12	Effect of virtual reality based rehabilitation on upper extremity function and visual perception in stroke patients: A randomized control trial/ 2012	Cho, K., Yu, J., & Jung, J	Twenty nine patients were randomly allocated into virtual reailty group (n=15) and control group (n=14)	The Interactive Rehabilitation and Exercise System: bird and balls, coconuts, drums, juggler, conveyor, and soccer games	WMFT, MVPT	Upper extremity function recovery and visual perception showed significant improvement after VR intervention ($p< 0.01$).
13	Effect of virtual reality-based bilateral upper-extremity training on brain activity in post stroke patients/ 2016	Lee, S., Kim, Y., & Lee, B. H	Eighteen chronic stroke patients recruited (experimental group (n=10) and control group (n=8)).	virtual reality-based bilateral upper-extremity training (VRBT)	A QEEG-8 (Laxtha Inc., Daejeon, Korea)	Brain activity improved (FP1, FP2, Fp3, FP4) after VRBT training ($p < 0.05$).

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; CAHAI= 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 Perception*Various VR interventions, intervention protocols, main outcomes from virtual reality intervention in patients with stroke*

The selectedstudies had various objectives regarding the effect of VR intervention on different physical function of the patients. The main outcomes of the studies were commonly to improve limb function (8 studies). Three studies reported the improvement in balance [9–11]. One study reported the improvement in visual perception [12] and the one study reported improved brain activity after the patients received VR intervention

[13]. 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 strokewhich 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 thanimmerse 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.

Acknowledgement

The authors would like to thank their colleague for their contribution and support to the research. They are also thankful to all the reviewers who gave their valuable inputs to the manuscript and helped in completing the paper.

Conflict of Interest

The authors have no conflict of interest to declare.

References

[1] Feigin, V. L., Abajobir, A. A., Abate, K. H., Abd-Allah, F., Abdulle, A. M., Abera, S. F.,... & Aichour, M. T. E. (2017). Global, regional, and national burden of neurological disorders during 1990–2015: A systematic analysis for the Global Burden of Disease Study 2015. *The Lancet Neurology*, *16*(11), 877-897.

[2] Ministry of Health Republic of Indonesia. (2018). Basic Health Research 2018. Retrieved from www.depkes.go.id/resources/download/info.../hasil-riskesdas-2018. pdf Barclay-Goddard, R. E., Stevenson, T. J., Poluha, W., Moffatt, M., & Taback, S. P. (2004). Force platform feedback for standing balance training after stroke. Cochrane Database of Systematic Reviews,(4).

[3] Saposnik, G., Teasell, R., Mamdani, M., Hall, J., McIlroy, W., Cheung, D.,... & Bayley, M. (2010). Effectiveness of virtual reality using Wii gaming technology in stroke rehabilitation: A pilot randomized clinical trial and proof of principle. Stroke, 41(7), 1477-1484.

[4] Kelly-Hayes, M., Beiser, A., Kase, C. S., Scaramucci, A., D'Agostino, R. B., & Wolf, P. A. (2003). The influence of gender and age on disability following ischemic stroke: The Framingham study. Journal of Stroke and Cerebrovascular Diseases, 12(3), 119-126.

[5] Crosbie, J. H., Lennon, S., McGoldrick, M. C., McNeill, M. D. J., & McDonough, S. M. (2012). Virtual reality in the rehabilitation of the arm after hemiplegic stroke: A randomized controlled pilot study. Clinical Rehabilitation, 26(9), 798-806.

[6] Flynn, S., Palma, P., & Bender, A. (2007). Feasibility of using the Sony PlayStation 2 gaming platform for an individual poststroke: A case report. Journal of Neurologic Physical Therapy, 31(4), 180-189.

[7] Sampson, M., Shau, Y. W., & James king, M. (2012). Bilateral upper limb trainer with virtual reality for post-stroke rehabilitation: case series report. Disability and Rehabilitation: Assistive Technology, 7(1), 55-62.

[8] Bang, Y. S., Son, K. H., & Kim, H. J. (2016). Effects of virtual reality training using Nintendo Wii and treadmill walking exercise on balance and walking for stroke patients. Journal of Physical Therapy Science, 28(11), 3112-3115.

[9] bin Song, G., & cho Park, E. (2015). Effect of virtual reality games on stroke patients' balance, gait, depression, and interpersonal relationships. Journal of Physical

Therapy Science, 27(7), 2057-2060.

[10] Lee, H. Y., Kim, Y. L., & Lee, S. M. (2015). Effects of virtual reality-based training and task-oriented training on balance performance in stroke patients. Journal of Physical Therapy Science, 27(6), 1883-1888.

[11] Cho, K., Yu, J., & Jung, J. (2012). Effects of virtual reality-based rehabilitation on upper extremity function and visual perception in stroke patients: A randomized control trial. Journal of Physical Therapy Science, 24(11), 1205-1208.

[12] 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.

[13] Lexico Dictionaries. (2019). Definition of virtual reality in English by Lexico Dictionaries. [online] Available at: https://www.lexico.com/en/definition/virtual_reality [Accessed 17 Aug. 2019].

[14] Howard, M. C. (2017). A meta-analysis and systematic literature review of virtual reality rehabilitation programs. Computers in Human Behavior, 70, 317-327.

[15] Hatem, S. M., Saussez, G., della Faille, M., Prist, V., Zhang, X., Dispa, D., & Bleyenheuft, Y. (2016). Rehabilitation of motor function after stroke: A multiple systematic review focused on techniques to stimulate upper extremity recovery. Frontiers in Human Neuroscience, 10, 442.

[16] Brochard, S., Robertson, J., Medee, B., & Remy-Neris, O. (2010). What's new in new technologies for upper extremity rehabilitation?. Current Opinion in Neurology, 23(6), 683-687.

[17] Tripette, J., Murakami, H., Ryan, K. R., Ohta, Y., & Miyachi, M. (2017). The contribution of Nintendo Wii Fit series in the field of health: A systematic review and meta-analysis. PeerJ, 5, e3600.

[18] Saposnik, G., Cohen, L. G., Mamdani, M., Pooyania, S., Ploughman, M., Cheung, D.,... & Nilanont, Y. (2016). Efficacy and safety of non-immersive virtual reality exercising in stroke rehabilitation (EVREST): A randomised, multicentre, single-blind, controlled trial. The Lancet Neurology, 15(10), 1019-1027.

[19] Subramanian, S. K., & Levin, M. F. (2011). Viewing medium affects arm motor performance in 3D virtual environments. Journal of Neuroengineering and Rehabilitation, 8(1), 36.

[20] Kim, B. R., Chun, M. H., Kim, L. S., & Park, J. Y. (2011). Effect of virtual reality on cognition in stroke patients. Annals of Rehabilitation Medicine, 35(4), 450.

[21] Shin, J. H., Kim, M. Y., Lee, J. Y., Jeon, Y. J., Kim, S., Lee, S.,... & Choi, Y. (2016). Effects of virtual reality-based rehabilitation on distal upper extremity function and

health-related quality of life: a single-blinded, randomized controlled trial. Journal of Neuroengineering and Rehabilitation, 13(1), 17.

[22] Santisteban, L., Térémetz, M., Bleton, J. P., Baron, J. C., Maier, M. A., & Lindberg, P. G. (2016). Upper limb outcome measures used in stroke rehabilitation studies: A systematic literature review. PloS One, 11(5), e0154792.

[23] Sullivan, K. J., Tilson, J. K., Cen, S. Y., Rose, D. K., Hershberg, J., Correa, A.,... & Duncan, P. W. (2011). Fugl-Meyer assessment of sensorimotor function after stroke: standardized training procedure for clinical practice and clinical trials. Stroke, 42(2), 427-432.