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REVIEW ARTICLE

EFFECT OF VIRTUAL REALITY IN GAIT PARAMETERS AMONG STROKE- A SYSTEMATIC NARRATIVE REVIEW

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ABSTRACT

Background of the study: Improving the lower limb (LL) motor recovery after stroke is a major task in order to improve the functional ability of the patient. We aim to complete a narrative review to determine the efficacy of virtual reality in Lower limb therapy approaches among post stroke. **Methodology**: A literature search was carried out. Overall, 14 Articles with 852 participants were included in the study. The patient who has had a stroke and received intervention virtual reality during practice of the treatment session: 14 studies were included in the review. Data Sources were searched from MEDLIWE, CINAHL and Cochrane library, Physiotherapy Evidence Database (PEDro) from 2000 till 2021.**Result:** The stroke patient who received VR interventions has showed improvement in their functional abilities. Various outcome measures were included in the studied Kinematic and kinetic gait parameters, 10 MWT, Functional walking ability, FUGL Meyer assessment(FMA-UE),Action reach arm test (ARAT), Wolf motor function test (WMFT), Box block test (BBT), Functional ambulation classification (FACO), Berg balance scale (BBS), Time up and go (TUG), Mini mental state examination (MMSE), Utrecht scale for evaluation of rehabilitation – participation (USER-P), Stroke specific quality of life(SS-QOL), Fatigue severity scale (FFS). **Conclusion:** This systematic narrative review reveals that VR intervention is effective to improve lower limb motor function, gait and balance functions of stroke patients. Virtual reality may allow therapists to deliver more repetitive training with more regular performance feedback and improving motor learning rate.

Key words: Stroke; Balance; Virtual reality; Gait; Rehabilitation

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INTRODUCTION

In stroke rehabilitation the recovery of gait is the major goal. Most of the patient who suffers from stroke has problems in various aspects like balance, coordination asymmetry and increased postural sway [(1)]. Balance plays a major role in maintaining the walking pattern and various functional tasks such as sitting and transformation sitting to standing and walking [(2)].

The gait pattern of individuals post-stroke is often characterized by difficulty in initiating movement, abnormal movement patterns on the affected side, decreased stance time on the paretic side, and premature toe off during terminal stance, as compared to healthy adults [(3,4)].

Balance problem can lead to abnormal weight distribution patterns, so that less weight is taken through the weak leg. This pattern affects the static and dynamic balance, or responses to external perturbations which is seen in people with stroke [(5)].

Due to abnormal gait pattern and to maintain the balance patients tends to develop compensatory movements which affects the both affected and unaffected side. [(6)] This compensation movements leads to limitation of movements and affects the functional ability of the stroke patients, hence in stroke rehabilitation fall prevention and improving the walking pattern is the main focus [(7)].

Virtual reality (VR) is a form of interactive simulation by using computer hardware and software, for giving the patient an experience similar to real-world event.[(8)]Various studies have been conducted to analyze the effectiveness of VR to improve the lower limb gait function and VR creates an environment which allows the patient to improve the motor skills[(9)].

In VR, the user needs to see the virtual environment (VE) displayed or projected in a head-mounted display, desktop computer, television, or screen. The sound and the sense of touch create a VE which allows the patient to interact and perform the motor activity. VR consists of a hardware and software which connects the user with the environment and gives them a real-world effect which allows them to perform their motor task in a more effective way [(10)].

METHODOLOGY

Search Strategy: A search to identify the articles to examine the effects of Virtual reality training in recovery of gait in subjects with stroke and records were identified. Data are collected from BIOMED CENTRAL, MEDLINE, EMBASE, ACRI Europa medicophysica, BMI, PEDRO, Cochrane central register of controlled trials (CENTRAL), American physical therapy association, Google Scholar etc. The key words are virtual reality, gait parameters, balance, FUGL – Meyer assessment (FMA- UE), Action reach arm test (ARAT), Wolf motor function test (WMFT), Box block test (BBT), Functional ambulation classification (FACO) , Berg balance scale (BBS), Time up and go (TUG), Mini mental state examination (MMSE).

Selection Criteria:

Randomized controlled trials published between 2000 – 2021 was included in this study, original research articles published in English language with confirmed diagnosis of stroke.

Exclusion Criteria were Sample included if patient with Down syndrome, if articles were published only as abstract, articles before 2000 and articles published in other languages.

Data Sources: Details of study parameters included in the study

Author name / study design	Article	Study duration/ sample size	Inclusion criteria	Intervention	Outcome measure	Result
Anat mirelman, Benjamin L.Patritti,Paolo Bonato, Judith E. Deutsch Randomized controlled study.2010	Effect of Virtual Reality Training on Gait Biomechanics of Individuals Post - Stroke	4 weeks / 15 men 3 women	Hemiparesis stroke with gait deficit	Study group (n=9) virtual reality (n=9) non virtual reality group	Kinematic and kinetic gait parameters	As a result of training, subjects in the VR group displayed a considerably greater increase in ankle power generation at push-off (p=0.036). The VR group demonstrated a higher post-training change in ankle ROM (19.5%) than the NVR group (3.3%). Significant differences in knee ROM on the affected side during stance and swing were discovered, with the VR group showing the greatest

						alteration. There were no significant changes in hip kinematics or kinetics after training.
Yu- Hyung Park, Chiho Lee, Byoung–Hee Lee Randomized controlled study, 2013	Clinical Usefulness of the Virtual Reality – Based Postural Control Training on the Gait Ability in Patients with Stroke	Sixteen weeks-stroke patients	Ability to walk independently. Able to understand.	Study group (VR, n=8) experimental group, (CPt,n=8) control group	GAIT Rite system for spatiotemporal gait ability 10 MWT for functional gait ability	Study revealed that VR group showed significant improvement, except for cadence at post training and follow-up within the experimental group. Study revealed that there is, no obvious significant improvement was observed within the control group. In between group comparisons, the experimental group (VR group) showed significantly greater improvement only in stride length

						compared with the control group (P< 0.05), however, no significant difference was observed in other gait parameters.
Ki Kun Cho, Min Kyu Kim, Hwang-Jae Lee, Wan Hee Lee Randomized controlled study, 2015	Virtual Reality Training with Cognitive Load Improves Walking Function in Chronic Stroke Patients	4 weeks - Chronic Stroke Patients	Hemiparesis resulting from a single stroke, Chronic phase. Able to walk with or without the use of assistive device, Able to under-stand and follow simple verbal instructions, No severe heart disease or uncon-trolled hypertension	Study group (n=12) VRTCL group (n=12) VR group	Spatio-temporal gait parameters (GAIT Rite)	Suggesting that efficacy of VRTCL on the walking function under the dual task condition VRTCL may be an effective method for the achievement of independent walking in chronic stroke patients
Aiwei Yang, Wei-Hsung Hwang, Yi-Ching Tsai, Fu-Kang Liu, Lin-Fen Hsieh, Jen-Suh Chern Randomized controlled study,2011	Improving Balance Skills in Patients Who Had Stroke Through Virtual Reality Treadmill Training	14 Stroke Patients	Hemiplegia resulting from a single cerebrovascular accident and not from trauma Brain tumor Surgery Any other etiology	Study group (n=7) Experimental group (n=7) control group	COP	There is no significant improvement in COP related measure.

Huihui Cai, Tao Lin, Lina Chen, Huidan Weng, Ruihan Zhu, Ying Chen, Guoen Cai Randomized controlled study, 2021	Evaluating the Effect of Immersive Virtual Reality Technology on Gait Rehabilitation in Stroke Patients	6 Months (Initial Stroke patient)	Aged 40-80 years Patients with ischemic cerebro-vascular disease who met the classification and diagnosis criteria of cerebrovascular disease confirmed by head CT or MRI scan. The first ever stroke and initial stroke onset of 1 Month or less, the patient can stand with the help of one person or with crutches and can walk at least 10 meters. Lower Limb muscle strength level of 3 or above.	Study Group (n=18) VRT group (n=18) non-VRT group	Primary Outcomes Functional walking ability. Secondary outcomes MMT strength, Motor function of lower limbs	This study revealed an improved method of stroke rehabilitation. which can be helpful for clinical decision-making and future practice
Ilona J.M. de Rooiji, Ingrid G.L. van de port, Michiel Punt, PimJ.M.Abbink-van Moorsel, MichielKortsmit, Ruben P.A.vanEijik,Johanna M.A. Visser-Meily, Jan-Willem G.Meijer	Effect of Virtual Reality Gait Training on Participation in Survivors of Subacute Stroke	6 Month	Diagnosed with stroke according to the World Health Organization Definition Stroke between 2 weeks and 6 months. Ability to walk without physical assistance, Age 18 to 80 years	Study group (n=28) VRT Group (n=27) Non-VRT Group	Utrecht scale for evaluation of rehabilitation-participation (USER-P)	This study reveals that there is no significant differences between the groups were found over time for the USER-P restrictions subscale (1.23;95% cl = -0.76 to 3.23) or

Randomized controlled study, 2021						secondary outcome measures Patients experience with VRT were positive, and no serious adverse events were related to the interventions .
Ilona J.M. de Rooiji, Ingrid G.L. van de port, Johanna M.A. Visser-Meily, Jan-Willem G.Meijer Randomized controlled study,2019	Virtual reality gait training versus non-virtual reality gait training for improving participation in subacute stroke survivors	6month and 2 weeks	Diagnosed with stroke according to the World Health Organization Definition. Stroke between 2 weeks and 6 months, Ability to walk without physical,	Study Group VRT group non-VRT group	Primary outcome USER-P Secondary outcome Frequency and Satisfaction scales of the USER-P Stroke Impact Scale-16(SIS-16) Timed-up and Go (TUG) Stroke Specific Quality of Life Scale (SS-QOL)	The results of the study provide insight into the effect of VR gait training on participation after stroke
Chi-Ho Lee, Yumi Kim, Byoung-Hee Lee	Augmented reality-based postural	6 month/ 21 stroke patients	A diagnosis of stroke for at least 6 months, not taking	Study Group Experimental	TUG, BBS, Gait velocity cadence,	The result of this study provide evidence in

Randomized controlled study, 2014	control training improves gait function in patients with stroke		medication that can affect balance, Mini-Mental State Examination score <24, no pain or disability associates with acute musculoskeletal conditions, sitting to side lying with moderate assistance, sitting for longer than 10 seconds without support, standing without support for 1 minute.	group(n =10) control group (n=11)	step length, and stride length on both the paretic and non-paretic side	support of incorporating an AR environment into postural control training for improving gait of stroke patients.
Davidecorbetta, Federico Imeri, Roberto Gatti Randomized or Quasi Randomized controlled study, 2015	Rehabilitation that incorporates virtual reality is more effective than standard rehabilitation for improving walking speed, balance and mobility after stroke	341 Participants	Adults (>18 years old) Clinical diagnosis of stroke (ischemic or hemorrhagic) No other pathological conditions affecting lower limb	VRBR using head mounted devices or conventional workstation.	Walking speed Balance Mobility	In total, 15 trials involving 341 participants were included. When VRBR replaced some or all of the standard rehabilitation, there were statistically significant benefits in walking speed (MD 0.15 m/s, 95% CI 0.10 to 0.19), balance (MD

						2.1 points on the Berg Balance Scale, 95% CI 1.8 to 2.5) and mobility (MD 2.3 seconds on the Timed Up and Go test, 95% CI 1.2 to 3.4). When VRBR was added to standard rehabilitation, mobility showed a significant benefit (0.7 seconds on the Timed Up and Go test, 95% CI 0.4 to 1.1), but insufficient evidence was found to comment about walking speed (one trial) and balance (high heterogeneity).
Alexander V. Zakharov, Vladimir A. Bulanov, Elena V. Khivintseva, Alexander V.	Stroke Affected Lower Limbs Rehabilitation Combinin	10 days 15 minutes daily Control (N = 27) and	Age 18–80 years with the first-occurred acute ischemic cerebral circulation, acute period of	visual and tactile biofeedback based on VR	Rivermead Mobility Index, Fugl-Meyer Assessment Lower	Significantly improves the performance of standard rehabilitation.

Kolsanov, Yulia V. Bushkova4and Galina E. Ivanova et al., Randomized controlled study 2020	g Virtual Reality with Tactile Feedback	Experimental (N = 35) groups.	cerebrovascular accident	immersion	Extremities scale, Berg Balance scale	
Saposnik G, Teasell R, Mamdani M, Hall J, McIlroy W, Cheung D, Thorpe KE, Cohen LG, Bayley M	Effectiveness of Virtual Reality Using Wii Gaming Technology in Stroke Rehabilitation	2-week Total (N=22)	18 to 85 years of age having a first-time ischemic or hemorrhagic stroke were eligible for the study.	VRWii gaming technology	Wolf Motor Function Test, Box and Block Test, and Stroke Impact Scale	Participants in the VRWii arm had a significant improvement in mean motor function
Luque-Moreno, Carlos &Kiper, Paweł& Solís Marcos, Ignacio & Agostini, Michela &Polli, Andrea &Turolla, Andrea & Oliva-Pascual-Vaca, Angel. (2021).	Virtual Reality and Physiotherapy in Post-Stroke Functional Re-Education of the Lower Extremity: A Controlled Clinical Trial on a New Approach	(VR + CP; n = 10) 1 h VR and 1 h of conventional physiotherapy v	diagnosis of a first stroke (ischemic or hemorrhagic	Virtual Reality	Functional Ambulatory Scale (FAC), Functional Independence Measure (FIM), Fugl-Meyer Assessment (FM), Berg Balance Scale (BBS), and Trunk Control Test (TCT)	The findings suggest that VR intervention is a viable therapeutic option for post-stroke functional re-education of the LE, with the potential to be an optimum complement to conventional physical therapy.

Miclaus, R. S., Roman, N., Henter, R., &Caloian, S. (2021) prospective, randomized trial	Lower Extremity Rehabilitation in Patients with Post-Stroke Sequelae through Virtual Reality Associated with Mirror Therapy	experimental group (n = 31) control group (n = 28)	stroke survivors after the subacute phase, at least six months post-stroke	virtual reality (VR) therapy and mirror therapy (MT)	Functional Independence Measure (FIM), Modified Rankin Scale (MRS), Modified Ashworth Scale (MAS), and Fugl Meyer Lower Extremity Assessment (FMLE). Manual Muscle Testing (MMT)	VR rehabilitation technology with MT exercises creates a more favorable environment for lower extremity rehabilitation in chronic patients after stroke, by combining several types of feedback, with an increased impact on neuroplasticity.
Felipe FA, de Carvalho FO, Silva ÉR, Santos NGL, Fontes PA, de Almeida AS, Garção DC, Nunes PS, de Souza Araújo AA. -2020 Randomised studies	Evaluation instruments for physical therapy using virtual reality in stroke patients: a systematic review	29 review articles	studies on patients with stroke undergoing therapy using VR	VR therapy	Fugl–Meyer Assessment WolfMotor Function Test	This study found that patients with stroke, treated or not with VR, had their functional responses evaluated by various instruments that had the same purpose, making it difficult to compare studies and to perform a

						meta-analysis to validate the importance of VR use in these patients
Anat mirelman,Benjamin L.Patritti,Paolo Bonato, Judith E. Deutsch Randomized controlled study.2010	Effect of Virtual Reality Training on Gait Biomechanics of Individuals Post - Stroke	4 weeks / 15 men 3 women	Hemiparesis stroke with gait deficit	Study group (n=9) virtual reality (n=9) non virtual reality group	Kinematic and kinetic gait parameters	As a result of training, subjects in the VR group displayed a considerably greater increase in ankle power generation at push-off (p=0.036). The VR group demonstrated a higher post-training change in ankle ROM (19.5%) than the NVR group (3.3%). Significant differences in knee ROM on the affected side during stance and swing were discovered, with the VR group showing the greatest alteration. There were no significant

						changes in hip kinematics or kinetics after training.
Yu- Hyung Park, Chi – ho Lee, Byoung– HeeLee Randomized controlled study, 2013	Clinical Usefulness of the Virtual Reality – Based Postural Control Training on the Gait Ability in Patients with Stroke	Sixteen weeks (stroke patient)	Ability to walk independently. Able to understand.	Study group (VR,n=8) experimental group,(CPt,n=8) control group	GAIT Rite system for spatiotemporal gait ability 10 MWT for functional gait ability	Study revealed that VR group showed significant improvement, except for cadence at post training and follow-up within the experimental group. Study revealed that there is, no obvious significant improvement was observed within the control group. In between group comparisons, the experimental group (VR group) showed significantly greater improvement only in stride length compared with the control

						group (P< 0.05), however, no significant difference was observed in other gait parameters.

RESULT

The stroke patient who received VR interventions has showed improvement in their functional abilities. Various outcome measures were included in the studied Kinematic and kinetic gait parameters, 10 MWT, Functional walking ability, FUGL Meyer assessment(FMA-UE), Action reach arm test (ARAT), Wolf motor function test (WMFT), Box block test (BBT), Functional ambulation classification (FAC), Berg balance scale (BBS), Time up and go (TUG), Mini mental state examination (MMSE), Utrecht scale for evaluation of rehabilitation – participation(USER-P), Stroke specific quality of life(SS-QOL), Fatigue severity scale (FFS).

DISCUSSION

Today a lot of physiotherapy interventions are available with specific features. This review aimed to find out the effectiveness of Virtual reality to improve gait parameters in stroke patients.14 articles were selected from BIOMED CENTRAL, MEDLINE, EMBASE, ACRI, Europa medico physica, BMI, PEDRO, Cochrane central register of controlled trials (CENTRAL), American physical therapy association, Google Scholar, Cochrane library etc.

Chi-Ho Lee etal, in his study with 21 sample conducted a study based on augmented reality training for 30 minutes per day 3 days per week for a period of 4 weeks provide evidence that AR environment into postural control training for improving gait in stroke patient. Davide Corbetta et al, conducted a Systematic review with meta-analysis of randomized trials and concluded that adding extra VRBR time to standard rehabilitation also has some benefits[11, 12].

Anat Mirelman et al evaluated gait biomechanics after training with a virtual reality support the potential for recovery of force and power of the lower extremity for individuals with chronic hemiparesis [(13)].

Han Suk Lee et al, conducted ameta-analysis to examine whether virtual reality (VR) training is effective for lower limb function as well as upper limb and overall function in chronic stroke patients and stated that effects of VR programs on specific outcomes were most effective for improving muscle tension, followed by muscle strength, activities of daily living (ADL), joint range of motion, gait, balance, and kinematics[14].

Huihui Cai et al, conducted a study with 36 patients with VR intervention and revealed that

VR is an improved method of stroke rehabilitation which can be helpful for clinical decision-making and future practice [15].

Alexander V. Zakharov et al, conducted a study in 2020 stated that application of rehabilitation with implicit interaction with VR environment produced by the robotics action has measurable significant influence on the restoration of the affected motor function of the lower limbs compared with standard rehabilitation therapy [(16)].

A pilot study conducted in the year 2010 states that VRWii gaming technology represents a safe, feasible, and potentially effective alternative to facilitate rehabilitation therapy and promote motor recovery after stroke. He also concluded that Virtual reality (VR) gaming systems are novel and potentially useful technologies that allow users to interact in 3 dimensions with a computer-generated scenario (a virtual world), engaging the mirror–neuron system [1)].

A recent study conducted in the year 2021 and stated that VR along with conventional showed a significant improvement in (FAC) Functional Ambulatory Scale and concluded that that the intervention with VR is a feasible treatment in the post-stroke functional re-education of the LE, with the potential to be an optimal complement of CP [18].

Roxana Steliana Miclaus et al conducted a study in the year 2021 and stated that virtual reality along with mirror therapy have better outcomes in lower extremity rehabilitation in post-stroke patients compared to standard physiotherapy[19].

A systematic review conducted in the year 2019 stated that VR in stroke rehabilitation results in significant improvements in motor function, muscle strength and balance in the lower limbs. Virtual reality (VR) technologies have been gaining importance in rehabilitation over the last 20 years[20].

CONCLUSION

This Systematic review concludes that various studies revealed that Virtual reality training is effective to improve the gait parameters in stroke patients. The video games used in therapeutic applications have advanced in recent years, particularly in terms of associating virtual stimuli with everyday situations. The image processing technology in the design of a system helps to motivate people with physical disabilities to increase the number of exercises performed, improving both the ability to move the affected limb as well as quality of life. This Systematic review concludes that various study reveals that Virtual reality training is effective to improve the gait parameters in stroke patients.

Conventional physiotherapy plus task specific training with a specific VR system optimize the results. The main role of the physiotherapist is important in the application and alteration of these with flexible software and hardware, to the individual demand of post-stroke clients. Overall treatment with VR is appropriate and boost the functional improvement. It also noticed that there was no significant trunk control reversal in all these studies. Because large figures of patients initiated with good trunk control. Virtual reality may allow therapists to deliver more repetitive training with more regular performance feedback, perhaps improving motor learning rate and Transfer of virtual reality-based gait and

balance training to community ambulation should be evaluated

Legion of studies have shown that VR technology combined with task-oriented training in stroke rehabilitation canister effectively to improve the lower limb function of stroke patients, it can also adequately advance the quality of life of stroke patients

Limitation

- Results are influenced by small samples
- Less publications were employed in the study.
- Inclusion of research with publication bias and diversity
- Recent studies abstract was not available/ The full text of one article was not available

REFERENCE

1. Dickstein R, Abulaffio N. Postural sway of the affected and non-affected pelvis and leg in stance of hemiparetic patients. Arch Phys Med Rehabil 2000; 81:364e7.
2. Pollock A, Baer G, Langhorne P, Pomeroy V. Physiotherapy treatment approaches for the recovery of postural control and lower limb function following stroke: a systematic review. Clin Rehabil 2007; 21:395e410.
3. Olney SJ, Griffin MP, Monga TN, McBride ID. Work and power in gait of stroke patients. Arch Phys Med Rehabil 1991; 72:309-14.
4. Winter DA. Biomechanical motor patterns in normal walking. J Mot Behav1983; 15:302–30.
5. Au-Yeung SS, Ng JT, Lo SK. Does balance or motor impairment discriminate the ambulatory status of stroke survivors? Am J Phys Med Rehabil 2003; 82:279e83.
6. Balasubramanian CK, Bowden MG, Neptune RR, Kautz SA. Relationship between step length asymmetry and walking performance in subjects with chronic hemiparesis. Arch Phys Med Rehabil 2007; 88:43e9.
7. Michaelsen SM, Dannenbaum R, Levin MF. Task-specific training with trunk restraint on arm recovery in stroke: randomized control trial. Stroke 2006; 37:186e92.
8. Kim JH, Jang SH, Kim CS, Jung JH, You JH. Use of virtual reality to enhance balance and ambulation in chronic stroke: a double-blind, randomized controlled study. Am J Phys Med Rehabil 2009; 88:693e701.
9. Deutsch J E, Paserchia C, Vecchione C, Mirelman A, Lewis JA, Boian R, et al. Improved gait and elevation speed of individuals post-stroke after lower extremity training in virtual environments. J Neurol Phys Ther 2004; 28:185e6.
10. Holden MK. Virtual environments for motor rehabilitation: review. Cyber psychol Behav 2005; 8:187e211.
11. Chi-Ho Lee, Yumi Kim, Byoung-Hee Lee, Augmented reality-based postural control training improves gait function in patients with stroke: Randomized controlled trial, Hong Kong Physiotherapy Journal, Volume 32, Issue 2.
12. Corbetta D, Imeri F, Gatti R. Rehabilitation that incorporates virtual reality is more effective than standard rehabilitation for improving walking speed, balance and mobility after stroke: a systematic review. J Physiother. 2015 Jul;61(3):117-24. doi: 10.1016/j.jphys.2015.05.017. Epub 2015 Jun 18. PMID: 26093805.
13. Mirelman A, Patritti BL, Bonato P, Deutsch JE. Effects of virtual reality training on gait biomechanics of individual's post-stroke. Gait Posture. 2010 Apr;31(4):433-7.
14. Lee HS, Park YJ, Park SW. The Effects of Virtual Reality Training on Function in Chronic Stroke Patients: A Systematic

Review and Meta-Analysis. Biomed Res Int. 2019 Jun 18; 2019:7595639.

15. Cai H, Lin T, Chen L, Weng H, Zhu R, Chen Y, Cai G. Evaluating the effect of immersive virtual reality technology on gait rehabilitation in stroke patients: a study protocol for a randomized controlled trial. Trials. 2021 Jan 25;22(1):91.
16. Zakharov AV, Bulanov VA, Khivintseva EV, Kolsanov AV, Bushkova YV, Ivanova GE. Stroke affected lower limbs rehabilitation combining virtual reality with tactile feedback. Frontiers in Robotics and AI. 2020 Jul 9; 7:81.
17. Saposnik G, Teasell R, Mamdani M, Hall J, McIlroy W, Cheung D, Thorpe KE, Cohen LG, Bayley M; Stroke Outcome Research Canada (SOR Can) Working Group. Effectiveness of virtual reality using Wii gaming technology in stroke rehabilitation: a pilot randomized clinical trial and proof of principle. Stroke. 2010 Jul;41(7):1477-84.
18. Luque-Moreno, Carlos & Kiper, Paweł & Solís Marcos, Ignacio & Agostini, Michela &Polli, Andrea & Turolla, Andrea & Oliva-Pascual-Vaca, Angel. (2021). Virtual Reality and Physiotherapy in Post-Stroke Functional Re-Education of the Lower Extremity: A Controlled Clinical Trial on a New Approach. Journal of Personalized Medicine. 11. 1210. 10.3390.
19. Miclaus, R. S., Roman, N., Henter, R., & Caloian, S. (2021). Lower Extremity Rehabilitation in Patients with Post-Stroke Sequelae through Virtual Reality Associated with Mirror Therapy. International journal of environmental research and public health, 18(5), 2654.
20. Felipe FA, de Carvalho FO, Silva ÉR, Santos NGL, Fontes PA, de Almeida AS, Garção DC, Nunes PS, de Souza Araújo AA. Evaluation instruments for physical therapy using virtual reality in stroke patients: a systematic review. Physiotherapy.2020 Mar; 106:194-210.

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