The Annals of the "Ştefan cel Mare" University of Suceava.
Physical Education and Sport Section. The Science and Art of Movement
eISSN 2601 - 341X, ISSN 1844-9131 Volum XV issue 2/ 2022

VIRTUAL REALITY BASED-THERAPY: TARGETING BALANCE IMPAIRMENTS TO IMPROVE GAIT IN STROKE

PhD Student, Gabriela Iuliana Cazac[1]
University of Pitesti - IOSUD[1]
gabriela.cazac@usm.ro[1]

Keywords: balance, rehabilitation, stroke, virtual reality

Abstract

In relation to their posture limitations stroke patients have difficulties in maintaining balance and this is reflected in gait performance which strongly affects independence in performing daily living activities. In this framework, the use of virtual reality devices may be helpful as it offers neuroplastic changes in stroke patients through several features such as goal-oriented task, specifity, repetitions, activation of mirror neuron system, enhacing brain reward system (motivation) shown to be important in neurological rehabilitation.

The present paper underlines the key aspects of stroke rehabilitation and how virtual reality technology can exploit the capacity of the central nervous system for functional reorganization and mediate recovery through neuroplasticity. The bottom line is that through improvements in balance we can influence other neurological deficits such as gait (via improvements in balance). We found VR to be a promising method with positive effects on stroke rehabilitation, a complementary method that can make the post-stroke rehabilitation fun. So indulge in the fun!

Introduction

The incidence of stroke is significant across the globe, and the resultant brain damage often carries significant functional limitations [1]. Depending on the nature and location of injury, individuals living with stroke can experience a large range of adverse physical, behavioural, emotional and cognitive impairments. To mention just a few, the patients can suffer from spasticity, changes in sensations (hypoesthesia, hyperesthesia, feeling unaware of the position and movement of limbs, dysesthesia or paresthesia)**,** vision problems (hemineglect, hemianopsia), poor short and long term memory, fatigue, communications deficits (aphasia), problems with balance and dizziness [2,3].

The patients frequently experience a spectrum of impairments that are unique and different to each individual but balance and gait disorders are the crucial features of stroke that can significantly interfere with their functions, resulting in activity and participations limitations and risk to falling [3,4]. The

ability to balance is essential to complete activities of daily living safely and independently.

One of the most important aims of rehabilitation in subjects affected by stroke is recovery of balance during static and dynamic activities to help the individual to walk and return to functional performance. They can return to daily life activities through acquisition of new motor skills and recovery or compensation of lost motor skills. This is not an easy objective to achieve, especially when considering the complexity of neurological disorders like stroke.

Recently, new advantages seem to be offered by technology within rehabilitation that can maximize the potential variables that align with neuroplastic processes needed in stroke rehabilitation: massed practice, repetition, task specific, novel and meaningful tasks [4].

Table 1. Summary of attributes of virtual reality that align with elements that drive neuroplasticity in stroke recovery [5].

Elements that drive neuroplastic change in recovery	Attributes of virtual reality
Task specific	Train movements that are identical to those required in real-life tasks
	Goal-oriented tasks
	Options to individualize to different challenge levels
Massed practice	Enriched environment
	Precise and consistent
Repetitive	Potential for abundant repetition of practice trials
Novel	Ensure optimal movement quality throught guidance technique
Challenge and motivation	Novelty of VR technology
	Feedback: knowledge of performance knowledge of results
	Proprioceptive feedback: Auditory, visual or tactile
	Competition against other players
	Match between cognitive and physical effort
	Goal-oriented tasks

Virtual reality allows for the possibility of delivering patient-specific opportunities for interaction with the environment via technology and can be used

to deliver meaningful and relevant stimulation to an individual's nervous system and thereby capitalise on the plasticity of the brain to promote motor learning and rehabilitation [6].

Virtual reality interventions can target many consequences of stroke, including reduced motor function, mobility, postural control, and cognitive impairments [7] and can be an effective way of increasing active movement in the hands and arms after stroke [4].

When a skill is repeatedly practiced, neural changes occur as a result of functional reorganization across many brain regions [6]. Gamification of rehabilitation has the potential to make recovery fun and challenging and allows for repetitive practice and provides for the stroke survivors a physical challenge that has one strong advantage over real-world rehabilitation: safety [4]. Exploitation of the neurophysiological reward mechanisms with dopaminergic system engagement can result in increased neural plasticity [7].

Stroke survivors often have deficits in motor control which include balance, postural control, proprioception and mobility impairments [8] as well as a reduced ability to perform self care and participation in social and community activities [9].

Balance is a heavily relied upon ability that consists of three sensory systems: somatosensory (sight and touch), vestibular (motion, equilibrium, and spatial orientation), and cerebellar, (coordinating motor activities and learning new motor skills) each system has specific functions that work in alliance to maintain a normal posture [10].

Balance requires integration of sensory information to assess the position of body in space [11] and is particularly important when dealing with those with neurological impairment such as stroke because a brain injury can and often does affect these systems and may experience balance impairments such as motor deficits that affect bodily position (lack of coordination in the limbs), vestibular deficits causing an unstable gait that can lead to falls [10]. The immersive style of virtual reality provides a realistic environment and can integrate multisensory stimulation of visual, auditory, tactile, and somatosensory systems [8].

The use of virtual reality in rehabilitation is shown to provide widespread cortical activation and the ability to provide visual, motor and somatosensory feedback to the user is paramount; the more relevant and realistic the input presented to the brain during training, the more valuable the training and the more likely this sensory information will be integrated and used to help re-organize the brain in a favourable manner [6].

Material-method

The present study investigates the influence of a virtual reality program aimed to improving balance and also, if it possible to translate this into an improved gait (via improvements in balance).

The subject of this paper was a 62-years old female diagnosed with a left side hemiparesis of the body after an ischemic stroke. The VR intervention were offered after the first month post-stroke, three times per week for 8 weeks, with sessions lasting approximately 30 minutes. The inclusion criteria was that the patient should have mobility and static stability in sitting and standing position, whithout any condition that affects cognitive function (the patient must to able to understand the tasks).

From the tests (BBS and DGI) we noticed that the patient has main problems with balance control (anticipatory postural adjustments, postural responces, sensory orientation, dynamic gait and biomechanical constraints).

The training was performed using Oculus Quest 2 VR Headset. This system provides fully immersive virtual environment through a head-mounted VR gaming set. The game used was: Richie's plank experience flying mode and Beat Saber. The most frequently used was Beat Saber in which the player holds a lightsaber in each hand and cuts blocks that are presented from different locations to the sound of music. The game difficulty is adjustable across a broad range, from extremely easy to extremely hard, and the volume of the music and special effects could be reduced to some extent to lower the risk of sensory overload. This game did not require the ability to press any buttons, which made it playable by individuals with limited finger movements.

The games were played in a sitting and then in a standing position. During the training, the physiotherapist was close by to determine any potential need for safety precautions.

Fig. 1. The subject playing the VR-game Beat Saber in sitting position.

Results

In table 1 and 2 are presented the results based on the Berg Balance Scale and Dynamic Gait Index.

Table 1 Berg Balance Scale

Assessment of balance	BBS after 1 months post-stroke	BBS after 8 weeks VR therapy
Sitting to standing	2	4
Standing unsupported	2	4

Sitting unsupported	1	3
Standing to sitting	1	4
Transfers	2	4
Standing with eyes closed	1	3
Standing with feet together	1	3
Reaching forward with outstretched arm	2	4
Retrieving object from floor	1	3
Turning to look behind	2	4
Turning 360 degrees	2	4
Plasing alternative foot on stool	2	4
Standing with one foot in front	2	4
Standing on one foot	1	3
Score	22/56 Medium fall risk	51/56 Low fall risk

Table 1 Dynamic Gait Index

Assessment of balance	DGI with support after 1 months post-stroke	DGI unsupported after 8 weeks VR therapy
Gait level surface	1	2
Change in gait speed	0	1
Gait with horizontal head turns	0	2
Gait with vertical head turns	0	2
Gait and pivot turn	0	2
Step over obstacle	0	2
Step aroung obstacle	0	2
Stairs	0	2
	1/24	15/24

Discussions

As we can see in the table, the potency of the virtual reality intervention session, provided a significant improvement in all sections of the Berg Balance and Dynamic Gait Index scales.

We classified the quality of the results high in rehabilitations for balance ability and independence in performing daily activities, but due to small numbers of study participants, adequately powered studies are required to confirm initial findings.

Conclusions

VR-based rehabilitation can exploit the capacity of central nervous system for functional reorganization through goal-oriented tasks, potential for abundant repetition of practice, novelty of VR technology, motivation, proprioceptive feedback, enriched environment or match between cognitive and physical effort, especially in combination with intense repetitions of the specific tasks.

As a result of exposure to this kind of intervention we found VR to be a promising method with positive effect on stroke rehabilitation, in improving ADL function and to increase overall conventional therapy. Furthermore, virtual reality activity might be more motivating and beneficial when used as an complementary to the usual care.

References

[1]. Katan, M., Luft, A. (2018). Global Burden of Stroke. *Semin Neurol, 38*(2), 208-211. doi: 10.1055/s-0038-1649503

[2] Zeng, H., Chen, J., Guo, Y., Tan, S. (2021). Prevalence and Risk Factors for Spasticity After Stroke: A Systematic Review and Meta-Analysis. Front Neurol. doi: 10.3389/fneur.2020.616097. PMID: 33551975; PMCID: PMC7855612.

[3] Ministerul sănătății, muncii și protecției sociale al Republicii Moldova (2020). Accidentul vascular cerebral ischemic Protocol national. Chișinău

[3] Tilson, J. K., Wu, S. S., Cen, S. Y. et al (2012). Characterizing and identifying risk for falls in the leaps study: a randomized clinical trial of interventions to improve walking post-stroke. *Stroke, 43*(2), 446-52. https://doi.org/10.1161/STROKEAHA.111.636258

[4] Levine, P. G. (2012). Stronger after stroke. Your Roadmap to Recovery. New York: Demos Health Publisher, p. 55-59, p. xix-xxi, 101-102 retrieved from https://b-ok.xyz/book/2189498/151f09

[5] Danielle E. Levac, Heidi Sveistru (2014). Motor Learning and Virtual Reality. In Patrice, L. (Tamar) Weiss, Emily, A. Keshner, Mindy, F. Levin *(Eds.)*, Virtual Reality for Physical and Motor Rehabilitation, Springer New York, p. 26

[6] Cheung, K.L., Tunik, E., Adamovich, S.V., Boyd, L.A. (2014). Neuroplasticity and Virtual Reality. In Patrice, L. (Tamar) Weiss, Emily, A. Keshner, Mindy, F. Levin *(Eds.)*, Virtual Reality for Physical and Motor Rehabilitation, Springer New York, p. 13-19

[7] Martha Gustavsson, Emma K. Kjörk, Mattias Erhardsson & Margit Alt Murphy (2022). Virtual reality gaming in rehabilitation after stroke – user experiences and perceptions, Disability and Rehabilitation, 44:22, 6759-6765, DOI: 10.1080/09638288.2021.1972351

[8] Chen, L., Lo, W.L., Mao. Y.R., Ding, M.H., Lin, Q., Li, H., Zhao, J.L., Xu, Z.Q., Bian, R.H., Huang, D.F. (2016). Effect of Virtual Reality on Postural and Balance Control in Patients with Stroke: A Systematic Literature Review. Biomed Res Int. doi: 10.1155/2016/7309272
[9] Laver, K.E., George, S., Thomas, S., Deutsch, J.E., Crotty, M. (2015).Virtual reality for stroke rehabilitation (Review). Published by John Wiley & Sons, Ltd., p.5, https://doi.org/10.1002/14651858.CD008349.pub4
[10] Randall, T. L. (2013). The Effects of Virtual Rehabilitation Following Acquired Brain Injury: A Feasibility Study. Electronic Thesis and Dissertation Repository. https://ir.lib.uwo.ca/etd/1526
[11] Lamontagne, A., Keshner, E.A., Bugnariu, N., Fung, J. (2014). Virtual Reality Reveals Mechanisms of Balance and Locomotor Imparirments. In Patrice, L. (Tamar) Weiss, Emily, A. Keshner, Mindy, F. Levin *(Eds.),* Virtual Reality for Physical and Motor Rehabilitation, Springer New York, p. 169