The Effect of Virtual Reality Game Training on Fear of Falling and Quality of Life After Subacute Ischemic Stroke

Joudy Gessal,* Brain Anggana,** Jonathan Prayogi Suyono**

*Physical Medicine and Rehabilitation Department of the Faculty of Medicine of Sam Ratulangi University, Manado, Indonesia
**Resident of Physical Medicine and Rehabilitation Department of the Faculty of Medicine of Sam Ratulangi University, Manado, Indonesia

Abstract

Introduction: *Fear of falling after a stroke can be caused by a lack of balance, muscle weakness, or impaired motor control. This can affect a patient's ability to move around and their overall quality of life after a stroke. However, virtual reality (VR) technology has the potential to help with this issue by providing simulated physical exercises that are safe and controlled. By combining VR rehabilitation with conventional stroke care, it's possible to improve a patient's ability to move around safely and their quality of life after a stroke.*
Methods: *An experimental study was conducted on 18 ischemic post-stroke patients who sought treatment at the Medical Rehabilitation Installation of Prof. Dr. R. D. Kandou Hospital Manado from June to July 2023. The study aimed to analyze the impact of VR game training using Xbox 360° and Kinect™ devices on fear of falling and post-stroke quality of life. The assessment of fear of falling was done using the Fall Efficacy Scale (FES) and quality of life using the EQ-5D. The intervention included four types of game exercises scheduled three times per week, with each session lasting 30 minutes with a total of eight sessions for each subject.*
Results: *Following VR game training, there was a significant reduction in fear of falling (t = 15.353, p < 0.001) and an improvement in quality of life across five dimensions of health problems as well as EQ-5D (t = 23.777, p < 0.001).*
Conclusion: *VR game training combined with conventional stroke care can reduce the fear of falling and improve the quality of life of post-stroke patients.*

Keyword: *Virtual reality, Fear of falling, Quality of life, Post-stroke, Rehabilitation.*

Korespondensi: Joudy Gessal
E-mail: *jgessal@gmail.com*

Efek Latihan Menggunakan Gim Virtual Reality terhadap Rasa Takut Jatuh dan Kualitas Hidup pada Pasien Pasca Stroke Iskemik Subakut

Joudy Gessal,* Brain Anggana,** Jonathan Prayogi Suyono**

*Departemen Ilmu Kedokteran Fisik dan Rehabilitasi, Fakultas Kedokteran Universitas Sam Ratulangi, Manado, Indonesia
**Residen Departemen Ilmu Kedokteran Fisik dan Rehabilitasi, Fakultas Kedokteran Universitas Sam Ratulangi, Manado, Indonesia

Abstrak

Pendahuluan: Rasa takut jatuh pada pasien pasca stroke disebabkan oleh hendaya keseimbangan, kelemahan otot atau kurangnya kontrol motorik. Penyebab inilah yang mempengaruhi mobilisasi dan kualitas hidup pasien pasca stroke. Akan tetapi, penggunaan virtual reality (VR) memiliki potensi untuk mengatasi masalah ini dengan mensimulasikan latihan fisik secara aman dan tekendali. Rehabilitasi dengan mengkombinasikan VR dan perawatan stroke convensional diharapkan mampu mengingkatkan kemampuan mobilisasi dan kualitas hidup pasien pasca stroke.

Metode: Penelitian yang dilakukan merupakan penelitian eksperimental dengan desain one grup pre-test and post-test pada 18 pasien pasca stroke yang dirawat di instalasi rehabilitasi medik Rumah Sakit Prof. Dr. R. D. Kandou Manado yang dimulai dari Juni hingga juli 2023. Penelitian ini menganalisa efek dari latihan gim VR menggunakan perangkat Xbox 360° dan Kinect™ terhadap rasa takut jatuh dan kualitas hidup pasca stroke. Penilaian rasa takut jatuh menggunakan instrument Falls Efficacy Scale (FES) dan kualitas hidup menggunakan EQ-5D. Intervensi yang diberikan merupakan empat jenis latihan permainan yang diberikan tiga sesi perminggu dengan durasi 30 menit per sesi dengan total delapan sesi untuk setiap subjek.

Hasil: Setelah latihan menggunakan gim VR, terdapat pengurangan rasa takut jatuh yang signifikan ($t = 15.353$, $p < 0.001$) dan peningkatan kualitas hidup pada lima dimensi masalah kesehatan dan EQ-5D ($t = 23.777$, $p < 0.001$).

Kesimpulan: Latihan menggunakan gim VR ditambah dengan perawatan stroke convensional dapat mengurangi rasa takut jatuh dan meningkatkan kualitas hidup pasien pasca stroke.

Kata kunci: Virtual reality, Ketakutan jatuh, Kualitas hidup, Pasca stroke, Rehabilitasi.

Introduction

Stroke is a severe medical condition that results from a disruption of blood supply to the brain, causing damage to brain tissue. It is the second leading cause of death globally, with 6.2 million deaths in 2019.[1] One common side effect of stroke is the fear of falling, which can arise due to impaired balance, muscle weakness, or loss of control over body movements. This fear can significantly impact the patient's mobility and quality of life. Limited mobilization of stroke patients can result in decreased physical fitness, limitations in daily activities, and social isolation. Patients may become hesitant to move due to fear of falling and further injury, which can impede their rehabilitation and recovery process.[2]

The use of Virtual Reality (VR) technology has demonstrated promising results in addressing issues faced by stroke patients. With VR, patients can participate in simulated

physical activities and exercises that are safe and controlled. They can experience the sensation of walking, moving, and interacting with realistic virtual environments.[3,4]

Virtual reality rehabilitation offers a unique opportunity for stroke patients to improve their physical and mental health. The virtual environment allows them to perform repetitive exercises and muscle strengthening, which can help enhance their coordination, balance, and physical strength. Moreover, the social interaction available in the virtual environment can help reduce social isolation and improve their overall quality of life.[4] Study by Ain, et al. found that virtual reality training in stroke patients can enhance upper limb motor function for stroke patients.[5] Another study by Ali AS, et al.[6] found that virtual reality can reduce risk of falling in stroke patients.

The most commonly used device in previous research was the Nintendo Wii. A study conducted by Karasu, et al.[7] has found that using VR training with Nintendo Wii can be an effective therapy alongside conventional therapy (CT) to improve both static and dynamic balance in stroke patients. Another study by Bang et al. also suggests that VR training can be beneficial for patients who require improved balance and walking ability.[8] Additionally, a study by Cortés-Pérez, et al.[9] has shown a significant improvement in balance, reduction of risk of falls, and perception of visual verticality in stroke patients. Furthermore, Cortés-Pérez, et al.[9] suggest that combining VR and CT neuro-rehabilitation programs results in greater improvements than each treatment individually.

hardware and software for gaming.[10] The Xbox 360° comes with a composite video connection, and components to connect it to a TV are shown in Figure 1.

The Kinect™ sensor is made specifically for the Xbox 360° video game device. Kinect™ gives players a Natural User Interface (NUI) where players can control the system/game using gestures or voice commands. The sensor is capable of detecting three dimensional objects in the real world. Kinect™ consists of an red, green, blue (RGB) camera, a depth sensor, and a multiarray microphone. The advantage of this sensor is its ability to capture three-dimensional data regardless of light conditions. The Kinect™ depth sensor can be set for near (seated) or far (default) settings. In the seated state, people within 0.4 - 3 meters are visible, although the recommended distance is 0.8 - 2.5 meters. In the default position, standing people within 0.8 - 4 meters can be detected. Motion detection using Kinect™ is becoming more popular in physical therapy and rehabilitation circles.[12]

Methods

This study used an experimental research design of one group pre-test and post-test design. The subjects of this study were subacute post stroke patients who sought treatment at the Medical Rehabilitation Installation of Prof. Dr. R. D Kandou Hospital Manado who met the inclusion criteria and could be included in the study. The research sample was taken by consecutive sampling and held after receiving
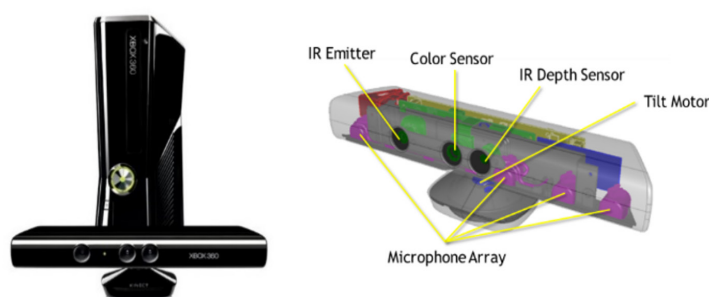

Figure 1. Xbox 360° console and Kinect™ censor.[11]

Another option for virtual reality training is to use a Microsoft® Xbox 360° (Washington, USA) console with a Kinect™ sensor for VR gaming. The Xbox 360° is a type of home video game console that functions like a regular computer, with specific hardware and software designed for gaming. In fact, the original Xbox was essentially a Windows PC with modified

ethical approval from Prof. Dr. R. D Kandou Hospital Manado (No.120/EC/KEPK-KANDOU/VII/2023). The study was conducted and reported using the modified CONSORT guidelines for non-randomized trials.

Inclusion criteria included first attack post-ischemic stroke patients, female or male who were at least 18 years old up to a maximum

of 60 years old when diagnosed with ischemic stroke, Montreal Cognitive Assessment (MoCA-Ina) indicate mild cognitive decline or no cognitive decline (score ≥ 18), modified Rankin scale indicate can perform independent activities to moderate dependence and can walk independently (score 1-2), ideal Body Mass Index (BMI) range from 18.5 to 24.9, normal or corrected vision function, normal hearing function tested by whisper test, willing and agreeing to take part in the study until completion and signing informed consent. While the exclusion criteria are the presence of neuromusculoskeletal disorders that can affect interventions such as pain, fracture, sprain, strain, infection, and malignancy, there are other cardiovascular conditions that are contraindications to physical exercise such as unstable angina, arrhythmias, decompensated heart failure, and grade two and three atrioventricular block, there is a history of photosensitive epilepsy, MAS score > two in the extremities. Then for the drop out criteria, the research subject did not attend training sessions more than two times during the study period and the research subject decided not to continue his participation in the study.

Inclusion criteria included first attack post-ischemic stroke patients, female or male who were at least 18 years old up to a maximum of 60 years old when diagnosed with ischemic stroke, MoCA-Ina indicate mild cognitive decline or no cognitive decline (score ≥ 18), modified Rankin scale indicate can perform independent activities to moderate dependence and can walk independently (score 1-2), ideal BMI range from 18.5 to 24.9, normal or corrected vision function, normal hearing function tested by whisper test, willing and agreeing to take part in the study until completion and signing informed consent. While the exclusion criteria are the presence of neuromusculoskeletal disorders that can affect interventions such as pain, fracture, sprain, strain, infection, and malignancy, there are other cardiovascular conditions that are contraindications to physical exercise such as unstable angina, arrhythmias, decompensated heart failure, and grade two and three atrioventricular block, there is a history of photosensitive epilepsy, Modified Ashworth Scale (MAS) score > two in the extremities. Then for the drop out criteria, the research subject did not attend training sessions more than two times during the study period and the research subject decided not to continue his participation in the study.

The types of Xbox and Kinect™ games used in this study include Kinect Sports: Table Tennis, Kinect Sports: Bowling, and

Your Shape: Run the World, all of which were conducted within 30 minutes per session and conducted as many as three sessions per week until reaching eight sessions for each subject. Due to time constraints, only 19 samples could be gathered.
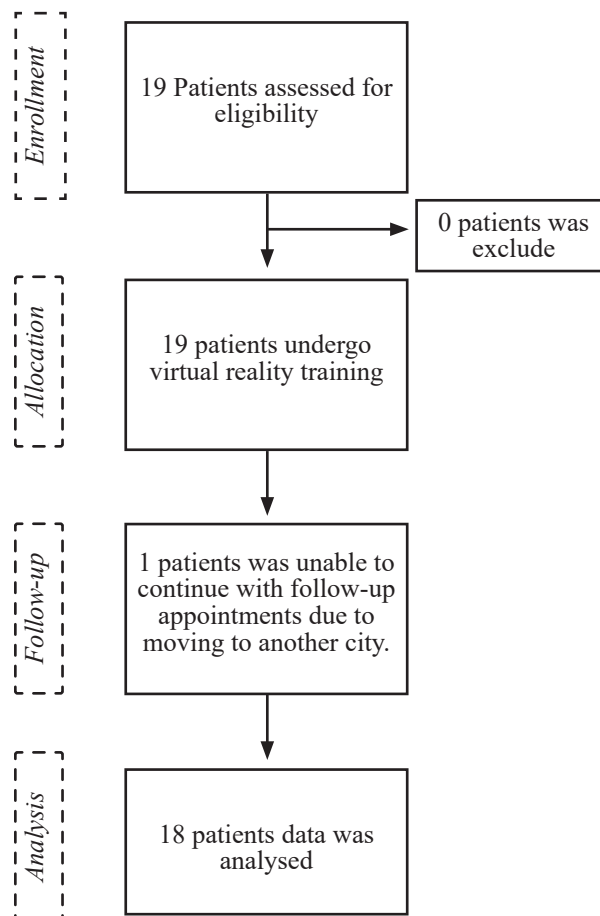

Figure 2. Modified CONSORT Flowchart for Non-randomized Trial Design Participants Enrollment

Before conducting VR game exercises, it is important to ensure that the patient is ready to participate safely and effectively. Here are some criteria to consider for patient readiness, namely general state assessment, comorbidity assessment, mobility and balance assessment, experience with VR, equipment and technical preparation, progressive approach, patient goals and preferences, and post-exercise feedback and monitoring.[12]

All data were analyzed using SPSS version 23, and data distribution was checked using the Shapiro-Wilk test. Normally distributed data were analyzed using the paired t-test. One follow-up was missed because the patient moved to another city, and the data was excluded from analysis.

During consecutive sampling at Prof. Dr. R. D Kandou Hospital in Manado, 19 patients become samples. After conducting the trial on the 19 samples, one patient had to be removed from the study as they moved to another city due to personal reasons. This study participant enrollment and subject distribution can be seen in figure 1 and Tables 1.

The Shapiro-Wilk Test was utilized to test for normality when the sample size was less than 30. The test results are presented that the fear of falling and quality of life data spread normally (p> 0.05). Therefore, the testing data normality can be seen in Table 2.

Table 1. Reasearch Subjects Distribution

Characteristic	Frequency (n)	Percentage (%)
Sex		
Male	12	66,7
Female	6	33,3
Total	18	100
Occupations		
Teacher	1	5.6
Housewife	6	33.3
Employee	2	11.1
Entrepreneur	1	5.6
Farmer	2	11.1
Private worker	3	16.7
Unemployed	2	11.1
TNI	1	5.6
Total	18	100
Marital Status		
Widower	1	5.6
Widow	1	5.6
Married	16	88.9
Total	18	100

Results of the difference in fear of falling and quality of life data before and after training can be seen in Table 3. The results show that the mean value of the fear of falling data before training is 81.78 higher than the mean value of the fear of falling data after training which is 56.33, which means there is a decrease in the mean value of the fear of falling data after training. The mean value of quality of life data before exercise is 18.61 higher than the mean value of quality of life data after exercise which is 11.56 So, there is a decrease in the mean value of quality of life data after exercise.

Table 2. Testing Data Normality

	Shapiro-Wilk		
	Statistic	df	*p*-value
Fear of fall	0.985	18	0.988
Quality of life	0.922	18	0.139

According to the results of a paired t-test, there is a significant difference in the mean value of fear of falling before and after training ($t = 15.353$; $p < 0.001$). Similarly, there is also a significant difference in the mean value of quality of life before and after training ($t = 23.78$; $p < 0.001$). Thus, there was an improvement in fear of falling and quality of life after the exercise.

Graphically, the difference in the distribution of fear of falling data and quality of life before and after VR game training using Xbox 360° and Kinect™ devices, can be seen in Figure 3. It can be seen in Figure 3 that the distribution of fear of falling and quality of life data after training is lower than the box of fear of falling and quality of life before training.

Discussions

This study is an experimental study with a one group pre-test post-test design that aims to analyze the effect of Virtual Reality game training using Xbox 360° and Kinect™ sensors on fear of falling and quality of life in subacute phase ischemic post-stroke patients. Fear of falling was analyzed by measuring the Falls Efficacy Scale and quality of life was analyzed by the EQ-5D questionnaire. This study was conducted for two months from the recruitment of subjects in June 2023 to the completion of the final evaluation in July 2023.

The research subjects used in this study were subacute ischemic post-stroke patients who were treated at the Medical Rehabilitation Installation of Prof. R.D. Kandou Hospital Manado. The number of subjects collected was 19 people who met the inclusion criteria. At the end of the study only 18 people completed the entire Virtual Reality game exercise. One subject was declared a drop out because he only attended the training session once due to the patient's move to another city for personal

matters. After each subject was given the intervention for 8 sessions, they will continue to undergo conventional stroke therapy for other unresolved functional problems. If there is a fall risk problem in the future, the subjects will be examined and reassessed.

Table 1 shows the distribution of the study sample based on marital status where it was dominated by married samples with partners who always drove and accompanied the samples during the study while for samples who were widowed or widowed, their biological

Table 3. Results of Fear of Falling Data and Quality of Life Pre and Post VR Game Training

	Mean Pre-Intervention	Mean Post-Intervention	Mean Difference	*t*-value	df	*p*-value
Fear of Falling	81.78 ± 5.39	56.33 ± 8.87	25.45 ± 10.37	15,353	17	< 0.001
Quality of Life	18.61 ± 2.52	11.56 ± 2.23	7.05 ± 3.36	23.777	17	< 0.001

Table 1 displays the gender distribution of the research subjects. There were 12 male (66.7%) and 6 female (33.3%) participants. This is in line with the stroke incidence by gender in Riskesdas 2018, where males have a higher incidence than females.[13] Recent studies by Yoon, et al.[14] have reported that women have a higher or similar stroke incidence rate compared to men in younger age strata. Thereafter, in middle age, men show higher stroke incidence rates than women. The difference in stroke incidence rates between men and women decreases with the increasing incidence of stroke in postmenopausal women, and finally, the incidence of stroke in women is close to or even higher than men in the eighth decade. With this small difference, it can be concluded that gender does not significantly affect the incidence of stroke.

Table 1 also displays the distribution of research subjects by occupation where most of the research sample occupations are housewives. The dominance of housewife occupations in the characteristics of the research sample is due to the fact that all female samples are housewives. In contrast to the male samples who have more diverse occupations. Apart from the sample characteristics, it turns out that several studies have also found a fairly high prevalence of stroke in the housewife group. Housewives today are developing a sedentary lifestyle that leads to a lack of physical activity. The duties of housewives are said to discourage them from participating in recommended physical activities as they are busy taking care of the household and taking care of children or grandchildren. This puts this demographic segment at greater risk of developing a condition as a result of long-term physical inactivity, such as cerebrovascular disease, cardiovascular disease, and metabolic syndrome.[15]

children always drove and accompanied them. This is important because the intervention for 8 sessions will not take place well without the cooperation and role of family members in supporting the post-stroke rehabilitation process of the subjects of this study. Study by Ramus, et al.[16] concluded that the rehabilitation process of stroke patients can be improved by paying attention to the role of spouses and family dynamics during the initial rehabilitation process and in long-term care.

Fall is an event that results in a person accidentally falling to the ground or floor or a lower level. Injuries from falls can be severe and lead to decreased quality of life for stroke survivors. Stroke has been identified as a risk factor for falls, primarily through impaired neuropsychological function and balance control. Impaired balance control post-stroke is a consequence of disruption of somatosensory afferent input to the central nervous system, interpretation of afferent input in the central nervous system, coordination between balance components namely visual, vestibular, and proprioception, muscle tone and/or strength and coordination of voluntary muscles.[17] Therefore, interventions that involve structured, repetitive, multisensory, and feedback balance training such as game training with VR are needed.

Balance therapy can be categorized into five main areas, namely exercise programs, biofeedback training, sensory training, cognitive training, and external devices.[17] In this study, researchers used Xbox 360° and Kinect™ devices that fall into the areas of exercise programs, cognitive training, and slightly incorporate sensory training. This can be explained where in the aspect of exercise programs, a series of structured and scheduled games have been arranged that will require patients to perform activities such as walking in place, stepping in various directions, reaching,

throwing, and bending. These activities require somatosensory input, afferent processing and interpretation in the central nervous system, coordination of balance components, and coordination of voluntary muscles so that when suitable for training balance after subacute stroke to improve good postural control so that it can reduce the fear of falling. Game training with Xbox 360° and Kinect™ also trains cognitive function as it requires the ability to understand game rules, analyze game situations, and respond to situations with an action according to game rules. These exercises also increased the subject's self-confidence as they were fun and task-oriented.

As the ability to maintain posture and self-confidence increases, there will be a significant decrease in the fear of falling as seen in this study. The effect of minimal fear of falling is increased ability to mobilize safely and confidently so that subjects can perform daily life activities better in order to achieve a better quality of life.
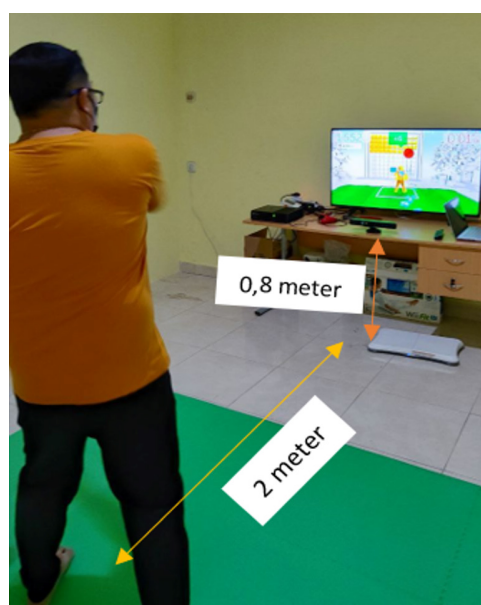

Figure 3. Ideal Room Setup for Game Practice with Xbox Consoles and Kinect™ Sensors.

Strength and Limitation

This study is the first study using VR game exercises at Prof. Dr. R. D Kandou Hospital Manado. Similar studies are often conducted in foreign institutions and some in the country, but not many have done so considering the cost efficiency and benefits that can be obtained by patients. This study proves that with a fairly affordable device, we can reduce the fear of falling and the subject's quality of life in 8-10 training sessions which then have a positive impact on the patient's ability to perform activities of daily living. The use of Virtual Reality game exercises also proved to be quite popular with patients and can increase adherence to exercise where structured, repetitive, and feedback exercise modalities such as this are effective for achieving Post-Stroke rehabilitation targets.

The limitation of this study includes the lack of safety means in order to prevent injury if the patient falls where the researcher only provides a mat on the exercise area to increase proprioception perception on the soles of the feet and so that the surface of the exercise area is not slippery like seen in Figure 3. Another limitation is that the clinical characteristics of the ischemic stroke to be studied were not specifically determined, for example by the Bamford classification where the lacunar subtype would certainly have a better prognosis than other subtypes. This study also did not apply a comparison with a control group that received conventional therapy so that the effectiveness of the intervention in this study cannot be compared with other rehabilitation modalities. It is important to acknowledge the limitations of this study due to a small sample size. Despite our efforts to acquire a larger sample, time constraints and difficulty in participant recruitment resulted in a sample size that was smaller than desired. In the future, research should explore ways to overcome these limitations and increase the sample size to better represent populations.

Conclusion

Virtual reality game training, using Xbox 360° device and Kinect™ sensor as a supplementary therapy, proved to be effective in reducing the fear of falling and improving quality of life after subacute ischemic stroke, after completion of 8 sessions of therapy. The use of virtual reality game exercises can significantly increase post-stroke patient's adherence to medical rehabilitation programs, as it has a fun element and helps increase self-confidence.

Conflict of Interest

None

Acknowledgement

Training on Fear of Falling and Quality of Life After Subacute Ischemic Stroke

References

1. World Health Organization. Leading causes of death and disability 2000-2019: A visual summary [Internet]. 2020. Available from: https://www.who.int/data/global-health-estimates.
2. Sarıçan Y, Erdoğanoğlu Y, Pepe M. The effect of body awareness on trunk control, affected upper extremity function, balance, fear of falling, functional level, and level of independence in patients with stroke. Top Stroke Rehabil. 2023 Oct;30(7):681-90.
3. Oliveira CB, Medeiros IRT, Greters MG, Frota NAF, Lucato LT, Scaff M, et al. Abnormal sensory integration affects balance control in hemiparetic patients within the first year after stroke. Clinics. 2017; 66(12):2043-8.
4. Sultan N, Khushnood K, Qureshi S, Altaf S, Khan MK, Malik AN, et al. Effects of virtual reality training using xbox kinect on balance, postural control, and functional independence in subjects with stroke. Games Health J. 2023;12(6):440-4.
5. Ain QU, Khan S, Ilyas S, Yaseen A, Tariq I, Liu T, Wang J. Additional effects of xbox kinect training on upper limb function in chronic stroke patients: A randomized control trial. Healthcare (Basel). 2021;9(3):242.
6. Ali AS, Shendy WS, Hassan A, Abdelmonem KA, Khatib AE. The impact of virtual reality training with a cognitive load on falling in stroke cases. NeuroQuantology. 2022;20(15);90-7.
7. Karasu AU, Batur EB, Karataş GK. Effectiveness of Wii-based rehabilitation in stroke: A randomized controlled study. J Rehabil Med. 2018 May 8;50(5):406-12.
8. Bang YS, Son KH, Kim HJ. Effects of virtual reality training using nintendo wii and treadmill walking exercise on balance and walking for stroke patients. J Phys Ther Sci. 2016;28(11):3112-5.
9. Cortés-Pérez, I, Nieto-Escamez FA, Obrero-Gaitán E. Immersive virtual reality in stroke patients as a new approach for reducing postural disabilities and falls risk: a case series. Brain Sci. 2020;10(5):296.
10. Beaulieu-Boire L, Belzile-Lachapelle S, Blanchette A, Desmarais PO, Lamontagne-Montminy L, Tremblay C, Tousignant M. Balance rehabilitation using Xbox kinect among an elderly population: A pilot study. J Nov Physiother. 2015;5(02):261.
11. Duarte N, Postolache O, Scharcanski J. KSGphysio Kinect serious game for physiotherapy. 2014 International Conference and Exposition on Electrical and Power Engineering (EPE); 2014 Oct 16-18; Iasi, Romania. 2014.
12. Hondori HM, Khademi M. A review on technical and clinical impact of microsoft kinect on physical therapy and rehabilitation. Journal Med Eng. 2014; 2014:1-16.
13. Ministry of Health of the Republic of Indonesia. National Basic Health Research Report 2018. Jakarta: Ministry of Health of the Republic of Indonesia; 2018.
14. Yoon CW. Bushnell CD. Stroke in women: a review focused on epidemiology, risk factors, and outcomes. Journal of Stroke.2023;25(1):2-15.
15. Fekadu G, Chelkeba L, Kebede A. Risk factors, clinical presentations and predictors of stroke among adult patients admitted to stroke unit of jimma university medical center, south west ethiopia: prospective observational study. BMC neurol. 2019;19(1):1-11.
16. Rasmus A, Orłowska E. Marriage and Post-stroke Aphasia: The Long-Time Effects of Group Therapy of Fluent and Non-fluent Aphasic Patients and Their Spouses. Front Psychol. 2020 Jul 7;11:1574.
17. Ortega-Bastidas P, Gómez B, Barriga K, Saavedra F, Aqueveque P. Post-stroke balance impairments assessment: clinical scales and current technologies. 2022; :1-16.