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Case Report

TO ASSESS THE EFFECTIVENESS OF COMBINING IMMERSIVE VIRTUAL REALITY WITH CONVENTIONAL PHYSIOTHERAPY IN IMPROVING POSTURAL BALANCE AMONG STROKE SURVIVORS BY ADDRESSING UPPER EXTREMITY IMPAIRMENTS

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ABSTRACT

This case series is done to identify whether addressing upper extremity (UE) impairment using Immersive Virtual Reality (IVR) with conventional therapy can lead to enhancements in postural balance among individuals who have experienced strokes. This case series involved six stroke patients spanning different age groups. The patients received a combination of conventional physiotherapy (PT) and Immersive Virtual Reality (IVR) treatments. Conventional PT sessions lasted one hour per day, five days a week, while IVR sessions were conducted for 30 to 45 minutes, three days a week. Primary outcome assessments included Brunnstrom grading for voluntary control (VC) of the upper extremities (UE), Berg Balance Scale (BBS), and motor components of the Functional Independence Measure (FIM) to evaluate functional independence. The integration of Immersive Virtual Reality (IVR) with traditional Physical Therapy (PT) has shown promising results in enhancing trunk motor recovery, balance, voluntary control of the upper extremities, and functional independence among stroke patients. The study examined factors such as age, time since the stroke occurred, and the number of IVR sessions required for improvement. All age groups responded positively to IVR treatment. A reduced number of IVR sessions was found to be sufficient for improving balance in patients with shorter post-stroke periods. Conversely, a greater number of IVR sessions were necessary to enhance Brunnstrom UE Voluntary Control, regardless of the duration since the stroke. Since this study is a case series, conducting a homogeneity analysis is crucial for interpreting the Functional Independence Measure (FIM). The study concluded that combining Immersive Virtual Reality (IVR) with conventional Physical Therapy (PT) for upper extremities (UE) led to enhancements in trunk control, balance, and functional independence. As a result, IVR stands out as a promising instrument that enhances neuroplasticity, engages patients actively, and facilitates integrated rehabilitation alongside traditional PT in various stages of stroke recovery.

Key words: Immersive virtual reality, Stroke, Upper extremity, Postural control

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INTRODUCTION

The incidence of stroke is rising in India, with it being the fourth leading cause of death and the fifth leading cause of disability. Approximately 1.8 million stroke cases are reported annually in India, equating to nearly one stroke every 40 seconds and one stroke-related death every four minutes.

Recent research indicates that over 80% of stroke patients experience impaired upper limb motor function, with only 30% to 40% showing some improvement after six months. Despite this, up to 66% of stroke patients still suffer from upper limb dysfunction, which is considered the most debilitating residual deficit [1].

In addition to UE dysfunction, another important problem in individuals with stroke is the use of the atypical body characterized by weakness and abnormal compensatory strategies. The trunk plays an important role as a central axis in stabilizing the proximal movements for functional movements of the extremities and smooth performance of distal movements [2].

Trunk control is the ability of the trunk muscles to allow the body to remain upright and shift weights to perform specific movements of the trunk so that the center of mass is within the base of support during static and dynamic postural adjustments.

When a healthy individual tries to reach out objects beyond their arm length, the trunk begins to move slightly before or simultaneously with their hand, but stroke patients with trunk impairment begin to move their trunk after the hand reaches its peak, leading to increased risk of fall and functional limitation like sit to stand, standing, walking. Therefore, to maintain balance and posture while moving to the upper extremity, trunk stability is required [2,3].

Conventional stroke rehabilitation typically focuses on training the trunk and upper extremities separately rather than as part of a comprehensive program. Traditional physiotherapy for stroke patients has typically involved facilitatory techniques, task-oriented approaches, balance training, and gait training, all of which have demonstrated effectiveness.

However, relying solely on these individual techniques for recovery often prolongs the rehabilitation process, resulting in emotional distress and disengagement from treatment, ultimately leading to a life characterized by impairment and disability. Therefore, to meet the demands brought on by the rising number of stroke sufferers and to improve the active participation of the patients, technology-based neurorehabilitation like virtual reality has become more prevalent in recent years [4].

Immersive Virtual reality (IVR) is regarded as a promising emerging treatment technology for the functional recovery of stroke patients through the principles of immersion, imagination, and interaction [5]. IVR can enhance functional recovery after brain damage, through intensive, repetitive, and engaging training and tasks.

This case series aims to establish whether the integration of Immersive Virtual Reality (IVR) and traditional therapy can enhance postural balance in stroke survivors by targeting upper extremity (UE) impairment.

MATERIALS AND METHODS

Study Design

A real-world case series was carried out with stroke survivors of 3 males and 3 females from various age groups with stroke classification of ischemic and hemorrhagic equally.

Inclusion criteria

The case series included patients who underwent regular rehabilitation after being discharged from the hospital.

Case Description

Patient -1

A 62-year-old male with a history of hypertension experienced a right ischemic stroke, resulting in weakness in the left upper and lower extremities for three months. He was undergoing standard therapy but encountered challenges in utilizing his left upper extremity for bimanual tasks such as dressing and bathing.

Patient- 2

A 62-year-old woman who suffered from a left middle cerebral artery (MCA) stroke presented with weakness in her right upper and lower extremities for three months. She had a medical history that included diabetes, hypertension, rheumatism, and heart disease. She was undergoing regular conventional physiotherapy but faced challenges with activities such as eating, grooming, dressing, and other functional tasks involving the upper extremities.

Patient- 3

A 72-year-old male was diagnosed with an acute infarct in the right corona radiata, leading to difficulties in using his left upper and lower extremities for six months. He has a history of chronic alcoholism. He is undergoing traditional treatment, including needling and Ayurvedic treatment. He experiences challenges with independent bed transfers, transitioning from sitting to standing, maintaining independent standing, and performing bimanual functional activities involving the upper extremities.

Patient- 4

A 60-year-old man with a right subarachnoid hemorrhage had cranioplasty. He has been experiencing left upper and lower extremity weakness for seven months. Known history of hypertension. He was receiving conventional therapy regularly. He had difficulty in the bimanual functional activities of the UE and independent walking.

Patient- 5

A 60-year-old male underwent cranioplasty following a right subarachnoid hemorrhage and has since been dealing with weakness in his left upper and lower extremities for seven months. He has a medical history of hypertension and has been consistently receiving conventional therapy.

He faces challenges with bimanual functional activities involving the upper extremities and struggles with independent walking.

Patient- 6

A 33-year-old woman experienced a left middle cerebral artery hemorrhage two years ago and subsequently underwent craniotomy. Following her stroke, she struggled with depression.

She received daily conventional therapy targeting her right upper extremity for one year but ceased treatment due to her depression. As a result, she encountered challenges with tasks such as dressing, eating, and grooming, transitioning from sitting to standing, maintaining independent standing, and walking.

Intervention Protocol

All patients underwent a neurorehabilitation protocol involving one hour of daily conventional physical therapy, accompanied by immersive virtual reality sessions lasting 30 to 40 minutes, administered three times weekly.

Conventional Therapy

Each patient received conventional PT sessions five days a week, incorporating passive stretching, facilitatory and inhibitory techniques, and static and dynamic balance training.

Immersive Virtual Reality (IVR)

Each patient underwent IVR sessions three times weekly, lasting 30 to 40 minutes each, with appropriate breaks. Treatment parameters included the number of IVR sessions (Table 2.1) and the selection of IVR therapeutic games (Table 2.2), tailored to different postures such as sitting, sitting standing, and standing, based on the individual's capabilities. After the IVR therapy sessions, a relaxation IVR program was implemented.

Study Variables

The primary variables evaluated in this case series comprise:

- Brunnstrom grading for voluntary control (VC) of the upper extremities (UE).
- Berg Balance Scale (BBS) for assessing balance.
- An additional motor component of the Functional Independence Measure (FIM), encompasses self-care, transfer, and locomotion.

Pre- and post-therapy outcomes for each outcome measure were compared.

Subjects Characteristics

Table 1.1: Socio-demographic characteristics

Patient (P)	Age	Gender	Comorbidities
P1	62	Male	Hypertension
P2	62	Female	Hypertension Diabetic Mellitus Rheumatic heart disease
P3	72	Male	Hypertension
P4	60	Male	Hypertension
P5	16	Female	Nil
P6	33	Female	Hypertension Depression

Table 1.2: Diagnosis

Patient (P)	Stroke type	Stroke lesion	Surgery	Hemiplegic side	Post-stroke period
P1	Ischemic	MCA	Nil	Left	3 months
P2	Ischemic	MCA	Nil	Right	3 months
P3	Ischemic	Corona Radiata	Nil	Left	6 months
P4	Hemorrhagic	Sub Arachnoid Hemorrhage	Cranioplasty	Left	7 months
P5	Hemorrhagic	Ganglio- capsular bleed	Craniotomy	Right	1 year 3 months
P6	Hemorrhagic	MCA	Craniotomy	Right	2 years

Table 2.1: Number of IVR sessions

Patient (P)	Age	Post-stroke period	No of IVR session
P1	62	3 months	6
P2	62	3 months	13
P3	72	6 months	23
P4	60	7 months	25
P5	16	1 year 3 months	20
P6	33	2 years	33

Table 2.2: Purpose of Rewin IVR therapeutic games

Therapeutic IVR Game	Purpose
Upper extremity • Penguin • Fruit Catch • Boxing	• Facilitate static and dynamic trunk control in sitting and standing through shifting of balance from side to side (weight distribution). • Improves postural reflexes. • Enhance UE voluntary control through reaching and grasping for the objects. • Facilitates shoulder girdle stability. • Position sense and movement sense of the UE. • Perception of the hand • Spatial relation
Relaxation • Focus Temple & Forest	• Relaxation • Reduces anxiety/ stress and depression. • Engages the patient more. • Provide positive feedback.

RESULTS

Improvements are evident in the comparison between pre-and post-treatment outcome measures. Tables 3.1 and 3.2 illustrate the pre- and post-analysis of Brunnstrom voluntary control for the upper extremities (UE) and Berg Balance Scale (BBS). Additionally, Tables 3.3, 3.4, and 3.5 depict the pre- and post-analysis of the self-care, transfer, and locomotion components of the Functional Independence Measure (FIM) for individual patients.

Brunnstrom voluntary control (VC) for UE

The Brunnstrom UE Voluntary Control (VC) is influenced by the post-stroke period and the number of IVR sessions. All the patients in this study were treated thrice weekly. P1 is a 3-month stroke treated with 6 IVR sessions for 15 days, the VC improved from strongest spasticity to minimal movements out of synergy. P2 is a 3-month stroke treated with 13 IVR sessions for 1 month, and their VC improved from minimal movement out of synergy to more movement out of synergy. P3 is a 6-month stroke treated with 23 IVR sessions for 2 months and their VC improved from flaccidity to emergence of spasticity.

P4 is a 7-month stroke treated with 25 IVR sessions for 2 months and their VC improved from minimal movements out of synergy to more movement out of synergy. P5 is a 1-year 3-month stroke treated with 20 IVR sessions for 2 months and their VC improved from minimal movements out of synergy to near normal movements. P6 is a 2-year stroke treated with 33 IVR sessions for 2 months and their VC improved from strongest spasticity to more movements out of synergy. From this, we can correlate the number of IVR sessions, and the post-stroke period influences the Brunnstrom UE VC.

Berg Balance Scale (BBS)

In our study, P1 and P2 are late sub-acute strokes and P3, P4, P5, and P6 are chronic strokes. Out of all patients, the P6 is a long-duration stroke of 2 years with 33 IVR sessions three times a week for almost three months, the balance improved from a wheelchair to walking with assistance. Following P6, P5 is the next long duration of stroke who was treated with 20 IVR sessions weekly thrice for 2 months, and balance improved from wheelchair to walking with assistance. P3 is a 6-month onset stroke with 23 sessions of IVR weekly thrice for 2 months and balance improved from wheelchair to walking with assistance. P1 and P2 is a 3-month stroke who had been given 13 sessions and 6 sessions of IVR weekly thrice for a month and 15 days and their balance improved from walking with assistance. P4 is a 7-month stroke with 25 sessions of IVR weekly thrice for 2 months, even though there is no improvement seen in the BBS, a difference in BBS scoring is observed from 29 to 38.

Functional Independence Measure (FIM)

The Functional Independence Measure (FIM) was utilized as an additional measure to assess improvements in functional status. For analysis, the self-care, transfers, and locomotion components of the FIM were considered. To calculate the overall score for each motor component for individual patients, the scores of all relevant subcomponents were summed and divided by the total number of subcomponents. The resulting value was then converted into a percentage for better analysis. For instance, if the subcomponents of self-care included eating (7 points), grooming (7 points), bathing (4 points), upper extremity (UE) dressing (2 points), lower extremity (LE) dressing (2 points), and toilet hygiene (4 points), the summed value would be 26. This value was divided by the total possible score (42) and multiplied by 100 to obtain the percentage score (e.g., (26/42) x 100) = 61%). Similar calculations were performed for post-FIM scores for all patients included in the case series.

Table 3.1: Brunnstrom voluntary control (VC) for UE

Patient (P)	Post-stroke period	Total Duration of IVR session (Weekly Thrice)	No of IVR session	Brunnstrom UE Voluntary control	
				Pre	Post
P1	3 months	15 days	6	3	4
P2	3 months	1 month	13	4	5
P3	6 months	2 months	23	1	2
P4	7 months	2 months	25	4	5
P5	1 year 3 months	2 months	20	4	6
P6	2 years	3 months	33	3	5

UE VC gradings: 1- flaccidity, 2- emergency of spasticity, 3- Strongest spasticity, 4- minimal movements out of synergy, 5- more movements out of synergy, 6- Near normal movements.

Table 3.2: Berg Balance scale (BBS)

Patient (P)	Post-stroke period	Total Duration of IVR Session (Weekly Thrice)	No of IVR session	Berg Balance Scale	
				Pre	Post
P1	3 months	15 days	6 sessions	10	40
P2	3 months	1 month	13 sessions	28	48
P3	6 months	2 months	23 sessions	7	34
P4	7 months	2 months	25 sessions	29	38
P5	1 year 3 months	2 months	20 sessions	10	40
P6	2 years	3 months	33 sessions	13	44

BBS: A score of 0-20 indicates wheelchair dependence, 21-40 indicates walking with assistance, and 41-56 indicates independence.

Self-Care

All patients in the study received treatment three times a week, but the number of immersive virtual reality (IVR) sessions and the post-stroke period varied among them. P1, P3, and P4 experienced left hemiplegia, resulting in independence in most self-care activities due to right-handed dominance. P1, with a stroke duration of three months, underwent six IVR sessions over 15 days, leading to an improvement in self-care components of the Functional Independence Measure (FIM) from 71% to 90%. P2, also with a stroke duration of three months, received 13 IVR sessions over one month, resulting in an improvement from 42% to 76% in the self-care components of FIM. P3, who experienced a stroke six months prior, underwent 23 IVR sessions over two months, resulting in an improvement from 61% to 76% in the self-care components of FIM. P4, with a stroke duration of seven months, underwent 25 IVR sessions over two months, leading to an improvement from 76% to 88% in the self-care components of FIM.

P5, who had a stroke one year and three months ago, received 20 IVR sessions over two months, resulting in an improvement from 66% to 85% in FIM scores. P6, who experienced a stroke two years ago, underwent 33 IVR sessions over three months, leading to an improvement from 45% to 71% in FIM scores. Thus, higher percentage scores in the FIM indicate reduced dependency and increased functional independence.

Transfer

The subcomponents of transfer include transfer to bed or chair, transfer to commode or toilet, and transfer to tub/ shower. All the patients in this study were treated thrice weekly, but the number of IVR sessions and the post-stroke period varied from patient to patient. P1 is a 3-month stroke treated with 6 IVR sessions, for 15 days and their transfer components of FIM improved from 66% to 85%. P2 is a 3-month stroke treated with 13 IVR sessions for 1 month and their transfer components of FIM improved from 57% to 85%. P3 is a 6-month stroke treated with 23 IVR sessions for 2 months. Their transfer components of FIM improved from 47% to 85%. P4 is a 7-month stroke treated with 25 IVR sessions for 2 months and their transfer improved from 76% to 90%. P5 is a year and 3-month-old stroke treated with 20 sessions for 2 months and their FIM improved from 76% to 90%. P6 is a 2-year stroke treated with 33 sessions for 3 months and their FIM improved from 47% to 80%. So, the higher the percentage score of FIM denotes less dependency and more functional independence.

Table 3.3: Self-care

Patient (P)	Post-stroke period	Total Duration of IVR session (Weekly Thrice)	No of IVR session	Self-care	
				Pre	Post
P1	3 months	15 days	6 sessions	71%	90%
P2	3 months	1 month	13 sessions	42%	76%
P3	6 months	2 months	23 sessions	61%	76%
P4	7 months	2 months	25 sessions	76%	88%
P5	1 year 3 months	2 months	20 sessions	66%	85%
P6	2 years	3 months	33 sessions	45%	71%

Table 3.4: Transfer

Patient (P)	Post-stroke period	Total Duration of IVR Session (Weekly Thrice)	No of IVR session	Transfer	
				Pre	Post
P1	3 months	15 days	6	66%	85%
P2	3 months	1 month	13	57%	85%
P3	6 months	2 months	23	47%	85%
P4	7 months	2 months	25	76%	90%
P5	1 year 3 months	2 months	20	76%	90%
P6	2 years	3 months	33	47%	80%

Locomotion

The subcomponents of locomotion include walking and stairs. All the patients in this study were treated thrice weekly, but the number of IVR sessions and the post-stroke period varied from patient to patient. P1 is a 3-month stroke treated with 6 IVR sessions, for 15 days and their locomotion components of FIM improved from 71% to 85%. P2 is a 3-month stroke treated with 13 IVR sessions for 1 month and their transfer components of FIM improved from 64% to 78%. P3 is a 6-month stroke treated with 23 IVR sessions for 2 months and their transfer components of FIM improved from 35% to 71%. P4 is a 7-month stroke treated with 25 IVR sessions for 2 months and their transfer improved from 78% to 92%. P5 is a year and 3-month-old stroke treated with 20 sessions for 2 months and their FIM improved from 64% to 92%. P6 is a 2-year stroke treated with 33 sessions for 3 months and their FIM improved from 42% to 78%. So, the higher the percentage score of FIM denotes less dependency and more functional independence.

Table 3.5: Locomotion

Patient (P)	Post-stroke period	Total Duration of IVR Session (Weekly Thrice)	No of IVR session	Locomotion	
				Pre	Post
P1	3 months	15 days	6	71%	85%
P2	3 months	1 month	13	64%	78%
P3	6 months	2 months	23	35%	71%
P4	7 months	2 months	25	78%	92%
P5	1 year 3 months	2 months	20	64%	92%
P6	2 years	3 months	33	42%	78%

DISCUSSION

In this series, the combination of immersive virtual reality (IVR) and conventional therapy has yielded favorable outcomes in motor recovery of the trunk, balance, and upper extremities, and overall functional improvement across acute, sub-acute, and chronic stroke cases. IVR facilitated learning by providing enriched environments, multisensory stimulation, and feedback mechanisms.

UE a catalyst to trunk, balance, and functional independence

The trunk, upper extremity functions, balance, and ADL are interrelated components [6, 7]. An investigation suggests that the ability of balance and walking in stroke subjects depends on the performance of trunk function and the longer hospital stay is determined by the poor trunk control [8]. Previous studies have reported that lack of proximal stabilization influences distal mobility, so training trunk control helps in the recovery of UE functions in stroke [2,3,6]. However, as a result of this case series, we can observe that training of UE with IVR also helps in improving trunk control, balance, and the overall functional independence of stroke survivors. Therefore, we can begin simultaneous UE and trunk training in the early phases of a stroke rather than individual segmental training, which will assist in faster recovery. While the Trunk Impairment Scale (TIS) is a reliable tool for assessing static and dynamic sitting balance and trunk coordination, it may not comprehensively address all aspects of trunk function and might lack sensitivity to subtle changes in trunk control observed in our case series. Therefore, we opted to utilize the Berg Balance Scale (BBS) instead of TIS for a more comprehensive analysis of postural balance.

Factors influencing functional recovery

Several factors can influence functional recovery like age, post-stroke period, and number of IVR sessions.

Age and Number of IVR sessions

This case series involved individuals across different age groups, including adolescents (16 years old), middle-aged adults (33 years old), and the elderly (60, 62, and 72 years old). As per this case series, the new innovative IVR was highly accepted and enjoyed by all age groups. From Table 2.1 there is no relationship seen in the age and the treatment dose (No of IVR sessions).

Post-stroke period and number of IVR sessions

A Cochrane review [9] found that the duration of time after a stroke had no discernible impact on the outcome. However, in this case series, the number of IVR sessions and the post-stroke period had a bigger impact on the outcome measures of VC, balance, and functional activities, which were investigated using the FIM, Brunnstrom VC for UE, and BBS.

Relationship between post-stroke period, number of IVR sessions, and balance

The observation from Table 2.4 is that the P1, P2 who are at 3 months post-stroke required only 13 and 6 sessions of IVR treatment for 15 days and 1 month to show an improvement in their balance from walking with assistance and wheelchair to independence in their balance. However, patients like P5, and P6 who are in the most long-standing post-stroke period of 2 years and 1 year 3 months require more IVR sessions of 33 and 20 sessions for 3 months and 2 months for their balance to improve from wheelchair to walking with assistance. This observation suggests that fewer IVR sessions are necessary to enhance balance when the post-stroke period is shorter. Research has demonstrated a connection between trunk muscle activation and UE movement, where trunk muscle activation precedes UE movement [10]. This discovery is relevant to our study, as our main goal was to evaluate whether UE control was enhanced with IVR therapy. However, we also observed an improvement in trunk control, which aids in balance and was measured using the BBS.

Relationship between post-stroke period, number of IVR sessions, and Brunnstrom VC

Table 3.1 shows that more IVR sessions are needed to show an improvement in the UE VC. Compared to P1, and P2, the P5, and P6, who got 20 and 33 IVR sessions, showed improvement in UE VC. Although P3 and P4 are classified as chronic stroke patients, they are in the transitional phase of the condition. So, despite receiving more virtual reality sessions, their VC has improved, but less than it has for P5 and P6. Thus, regardless of the duration of post-stroke time, more IVR sessions are required to exhibit improvements in Brunnstrom VC. However, our thorough investigation found no evidence to support this assertion.

Relationship between post-stroke period, number of IVR sessions, and FIM

In this study, the motor components of FIM self-care, transfer, and locomotion were taken into analysis. Since the FIM is a continuous scale, the single summed raw score could be misleading. Therefore, for improved data representation and analysis in this case series, the FIM scores were converted into percentages. A higher percentage score on the FIM signifies reduced dependency and increased functional independence.

Given the diverse characteristics of the patients in this case series, including variations in the side of stroke, post-stroke duration, and sociodemographic factors, factors like handedness may potentially influence FIM outcomes. Tables 3.3, 3.4, and 3.5 indicate that the relationship between the motor components of the FIM, the number of IVR sessions, and the post-stroke period is not significantly different. A more homogeneous dataset might provide a clearer understanding of these relationships.

CONCLUSION

The case series findings revealed an interrelationship between trunk and upper extremity (UE) functions, impacting both balance and activities of daily living (ADL). Although the focus was enhancing UE function through immersive virtual reality (IVR), notable improvements were observed in balance and functional independence concurrently. Motor recovery was influenced by factors such as the post-stroke period and the frequency of IVR sessions. Consequently, IVR emerges as a promising tool that actively involves patients and contributes to comprehensive rehabilitation alongside conventional physical therapy (PT) across varying stages of stroke, including acute, sub-acute, and chronic phases.

Way Forward

Although existing evidence indicates positive results with immersive virtual reality (IVR), a more focused study is necessary to determine the ideal dosage in terms of session duration, frequency of IVR sessions, and post-stroke duration. This investigation aims to enhance the effectiveness of therapy and fully utilize IVR's potential to improve patient outcomes.

Limitation of the study

In the future, studies can be done with a larger sample size.

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REFERENCES

1. Turolla A, Dam M, Ventura L, Tonin P, Agostini M, Zucconi C. (2013). Virtual reality for the rehabilitation of the upper limb motor function after stroke: A prospective controlled trial. *J Neuroeng Rehabil*. 10(1).
2. AYDOĞAN ARSLAN S, UĞURLU K, DEMİRCİ C, KESKİN D. (2021). Investigating the relation between upper extremity function and trunk control, balance and functional mobility in individuals with stroke. *Journal of Health Sciences and Medicine*. 4(2), 127–31.
3. Wee SK, Hughes AM, Warner MB, Brown S, Cranny A, Mazomenos EB. (2015). Effect of trunk support on upper extremity function in people with chronic stroke and people who are healthy. *Phys Ther*. 95(8), 1163–71.
4. Hao J, Xie H, Harp K, Chen Z, Siu KC. (2022). Effects of Virtual Reality Intervention on Neural Plasticity in Stroke Rehabilitation: A Systematic Review. 103, Archives of Physical Medicine and Rehabilitation. W.B. Saunders, 523-41.
5. Bui J, Luauté J, Farnè A. (2021). Enhancing Upper Limb Rehabilitation of Stroke Patients with Virtual Reality: A Mini Review. Vol. 2, Frontiers in Virtual Reality. *Frontiers Media S.A*.
6. Baby L, Joy A, KV R. (2021). Relationship between Trunk Impairment and Upper Extremity Function, and Its Impact on Activities of Daily Living in Chronic Stroke Survivors. *International Journal of Science and Healthcare Research*. 6(4), 220–7.
7. EKMEKÇİOĞLU Z, KATIRCI KIRMACI Zİ, ERGUN N. (2023). The Relationship of Trunk Control with Lower Extremity Sense, Balance, and Walking in Individuals with Stroke. *Clinical and Experimental Health Sciences*. 13(3), 530–6.
8. Karthikbabu S, Chakrapani M, Ganeshan S, Rakshith KC, Nafeez S, Prem V. (2012). A review on assessment and treatment of the trunk in stroke: A need or luxury. *Neural Regen Res*. 7(25), 1974–7.
9. Laver KE, Lange B, George S, Deutsch JE, Saposnik G, Crotty M. (2017). Virtual reality for stroke rehabilitation. Cochrane Database of Systematic Reviews. *John Wiley and Sons Ltd*.
10. Lee DH, Park H, Han JW. Effect of bilateral upper extremity exercise on trunk performance in patients with stroke.

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