

Visuo-Proprioceptive Illusion and Motor Imagery Using Immersive Virtual Reality to Improve Hand Functions and Spasticity in Sub Acute Stroke: A Case Study

Dr. Richa Uniyal¹, Dr. Sharda Sharma², Pooja Yadav³, Dr. Deepak Kumar⁴, Sachi Saxena⁵

¹Department of Physiotherapy, Dev Bhoomi Uttarakhand University, Dehradun

Email: uniyalricha6@gmail.com

ORCID: 0009-0004-9125-9938

²Department of Physiotherapy, Shri Guru Ram Rai University, Patel Nagar, Dehradun, Uttarakhand

Email: shardasharma.physio@gmail.com

ORCID: 0009-0006-6538-7842

³Department of Physiotherapy, Sardar Bhagwan Singh University, Balawala, Dehradun, Uttarakhand

Email: ptpoojayadav90@gmail.com

⁴Department of Physiotherapy, SSSMC, Ras Bihari Bose Subharti University, Dehradun

Email: deep841077@gmail.com

⁵Department of MSC AOTT, Maharaja Ranjit Singh Punjab Technical University

Email: sachisaxena19@gmail.com

ORCID: 0009-0001-9726-8091

Received: 5th January, 2026; Revised: 18th January 2026; Accepted: 25th January, 2026; Available Online: 28th January, 2026

ABSTRACT

Background:

Stroke ranks among the leading causes of global disability, with post-stroke stiffness and diminished hand functionality presenting significant challenges. The subacute stage of stroke (1–6 months) is characterized by heightened neuroplasticity, making it an ideal period for rehabilitation. Techniques such as visuo-proprioceptive illusion, motor imagery, and tendon vibration have favorable outcomes, although they have not been concurrently evaluated.

Objective:

The objective of this case study was to evaluate the effectiveness of integrating immersive virtual reality, motor imagery, and tendon vibration with traditional physiotherapy to improve upper limb function and reduce spasticity in a subacute stroke patient.

Methods:

A 59-year-old female patient, who had experienced an ischemic stroke in the left middle cerebral artery four weeks prior, completed a six-week rehabilitation program. The therapeutic regimen included physiotherapy, visuo-proprioceptive illusion via virtual reality (VR) aligned with tendon vibration at 100 Hz, motor imagery training focusing on kinesthetic aspects, and more challenging activities in virtual reality. Outcome measures included the Fugl-Meyer Assessment for Upper Extremity (FMA-UE), Nine-Hole Peg Test (NHPT), Box and Block Test (BBT), grip strength, and pinch strength.

Results:

Enhancement was observed across all domains. FMA-UE scores increased from 30 to 56 during a period of six weeks. The NHPT duration decreased from 102 to 48 seconds, but the BBT score increased from 16 to 43 blocks per minute. A significant enhancement in pinch strength was observed: tip pinch increased from 1.3 kg to 4.5 kg, lateral pinch from 2.0 kg to 5.8 kg, and three-jaw chuck pinch from 1.6 kg to 5.0 kg. Diminished spasticity was observed in MTS scores, with wrist flexor X decreasing from 2 to 1 and finger flexor X from 3 to 1.

Conclusion:

A combination of virtual reality, motor imagery, tendon vibration, and conventional physiotherapy produced beneficial outcomes on motor control, dexterity, grip strength, and spasticity within just six weeks. It is plausible that the interplay of sensory illusion, mental repetition, and proprioception induced neuroplasticity during the subacute phase. Despite the promising outcomes, further randomized controlled studies are necessary to validate the efficacy and longevity of the method.

Keywords: Stroke Rehabilitation; Virtual Reality; Motor Imagery; Tendon Vibration; Upper Limb Function; Spasticity.

How to cite this article: Richa Uniyal¹ Dr. Sharda Sharma² Pooja Yadav³ Dr. Deepak Kumar⁴ Sachi Saxena⁵. Visuo-Proprioceptive Illusion and Motor Imagery Using Immersive Virtual Reality to Improve Hand Functions and Spasticity in Sub Acute Stroke: A Case Study. *Int J Drug Deliv Technol.* 2026;16(85s):604-607. DOI: 10.25258/ijddt.16.85s.58.

Source of support: Nil.

Conflict of interest: None

Introduction

Stroke is a leading cause of mortality and disability worldwide, with millions of new cases reported annually, and a substantial proportion of survivors experiencing functional impairments. Post-stroke spasticity results from lesions in higher motor neurons, which disrupt inhibitory circuits, leading to hyperirritability of the stretch reflex and heightened muscle tone. The subacute stage (1-6 months) is a pivotal period for spontaneous neurological recovery, characterized by heightened neuroplasticity and cortical rearrangement, making it an opportune time for focused rehabilitation efforts. [1]

Tendon vibration at frequencies between 80-100 Hz induces proprioceptive illusions that activate muscle spindle afferents and enhance corticospinal excitability, resulting in motor cortex activity. Similarly, motor imagery activates the primary motor, premotor, and supplementary motor areas without actual movement, engaging neuronal pathways that are amenable to voluntary control. [4] [2]

A 59-year-old left-hand dominant female presented for physiotherapy four weeks post her initial left middle cerebral artery (MCA) ischemic infarction. She reported weakness in the right upper limb, trouble with fine motor skills in the hand, and increased stiffness that impacted her daily activities.

The patient presented with:

- Right upper limb weakness
- Reduced hand dexterity
- Difficulty grasping and releasing objects
- Frequent dropping of light weight objects
- Increased muscle tone of the wrist and finger flexors
- Reduced participation in self-care activities such as dressing and feeding

The patient had a medical history of well-managed hypertension and type 2 diabetes mellitus for eight years. No prior history of stroke, seizure, or other neurological issues. Her cognitive, verbal, visual, and communication abilities remained intact, enabling her to participate well in VR and MI training.

Baseline Clinical Assessment Findings Clinical assessment demonstrated:

- Impaired selective voluntary finger movements
- Weak tip pinch, tripod pinch, and lateral pinch
- Reduced grip strength
- Slowed reach-to-grasp performance

- Poor object manipulation and coordination
- Mild spasticity affecting wrist and finger flexor muscles
- Difficulty performing precision tasks such as buttoning clothes and writing

Outcome Measures

1. Fugl-Meyer Assessment–Upper Extremity(FMA-UE)
2. Modified Tardieu Scale(MTS)
3. Nine Hole Peg Test (NHPT)
4. Box and Block Test (BBT)
5. Grip Strength (Hand Dynamometer)
6. Tip Pinch Strength
7. Lateral Pinch Strength
8. Three-Jaw Chuck Pinch Strength

Intervention

Conventional Physiotherapy

Treatments were conducted five days per week for six weeks, with each session lasting around 45 minutes.

The programme included:

- Active-assisted and active range of motion exercises
- Stretching of wrist and finger flexor muscles
- Strengthening exercises for shoulder, elbow, wrist, and hand muscles
- Scapular stabilization exercises
- Task-oriented reach and grasp training
- Functional object manipulation activities
- Fine motor coordination exercises
- Home exercise programme

Immersive VR, Motor Imagery and Tendon Vibration Protocol Equipment

- Meta Quest3 Virtual Reality Headset
- Hand Physics Lab application
- Portable tendon vibration device(100 Hz)

Session Structure

Phase1: Visuo-Proprioceptive Illusion (10 minutes)

The participant was directed to observe a virtual depiction of the affected hand, which vibrated in synchrony with a 100 Hz focal tendon vibration, while reaching for, grasping, and releasing an object with the affected hand in the immersive virtual environment, as the hand extended the wrist and fingers. This resulted in a congruent visuo-proprioceptive illusion of typical hand movement.

Phase2: Motor Imagery Training (10minutes)

The participant was instructed to imagine performing the following movements without actual execution:

- Wrist extension
- Finger opening

Visuo-Proprioceptive Illusion and Motor Imagery Using Immersive Virtual Reality to Improve Hand Functions and Spasticity in Sub Acute Stroke: A Case Study

- Thumb opposition
- Grasping cup
- Picking up coins
- Releasing small objects
- Manipulating virtual household objects/

Motor imagery sessions were performed using kinesthetic imagery with therapist-guided verbal cues.

Phase3: Virtual Reality Task Practice (25minutes)

The participant completed progressively challenging VR activities including:

- Grasping cubes and spheres
- Picking up virtual household objects
- Releasing objects into designated targets
- Peg placement activities
- Simulated kitchen tasks
- Virtual grocery sorting
- Fine object manipulation games
- Functional activities of daily living

The difficulty of the exercise was incrementally heightened by altering the speed of movement, the size of the objects, and the complexity of the assignment on a weekly basis.

Diagnosis: Right upper limb hemi paresis was the initial ischemic infarction of the left middle cerebral artery (Subacute Stage).

Physical Examination

The patient was attentive, compliant, aware, and medically stable upon evaluation. She demonstrated weakness in her right upper limb, characterized by compromised voluntary motor control and diminished movement coordination. The wrist and finger flexor muscles exhibited increased muscular tone, indicative of mild-to-moderate spasticity.

The active range of motion in the fingers, wrist, elbow, and shoulder on the affected side was decreased compared to the unaffected side. The patient had challenges in grabbing and releasing objects, delayed finger extension, reduced manual dexterity, and trouble handling small items, resulting in the dropping of objects during functional activities.

Manual Muscle Testing indicated muscle strength ranging from 3/5 to 4-/5 in the shoulder, elbow, wrist extensors, finger extensors, and intrinsic hand muscles. A notable reduction in grip strength and pinch strength occurred. The sensory assessment indicated appropriate responses to mild touch, pain, temperature, and proprioception. Coordination assessment revealed diminished fine motor control, reduced quick alternating motions, and compromised finger-to-thumb opposition.

The patient demonstrated the ability to sit, stand, and walk autonomously without the need of assistive aids. However, tasks requiring intricate hand movements such as dressing, grooming, utensil-based eating, writing, buttoning, and transporting lightweight household items were significantly impaired. The patient's cognitive function, attention, understanding, memory, and communication abilities were preserved, enabling

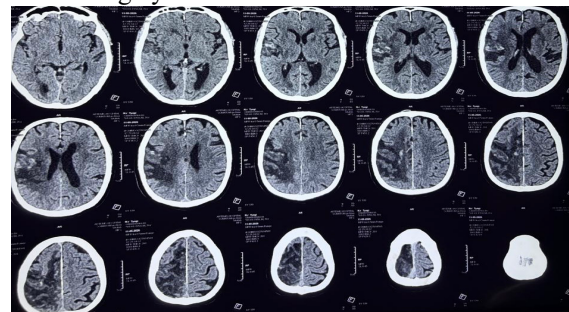
active participation in the rehabilitation program.

Radiographic Findings

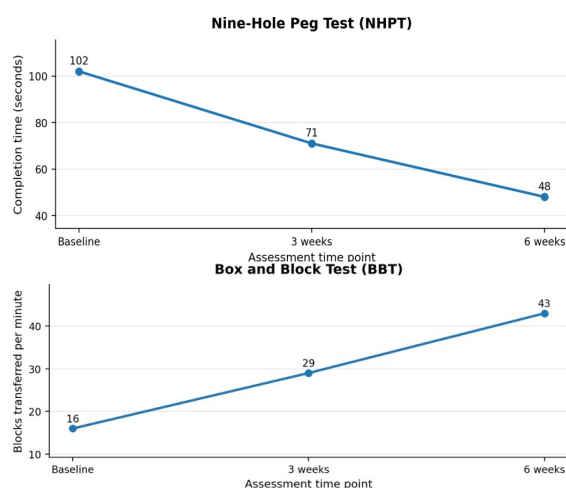
This case illustrated important radiographic findings to help understand the possible etiology of the patient's upper limb dysfunction. CT scan showed an acute to subacute infarction in the left fronto-parietal area in the territory of the middle cerebral artery (MCA). This region includes the main motor cortex and nearby upper limb sensorimotor pathways that are directly involved in the voluntary control of the Contralateral upper limb. Damage here is responsible for the patient's right side weakness, poor coordination and spasticity. The lack of ICPH and midline shift implied a focal ischemic event with no secondary complications, so that more specific rehabilitation could be implemented.

The involvement of the motor cortex and associated sensory motor tracts resulted in disruption of corticospinal output, resulted in decreased dexterity, increased flexor muscle tone in the fingers and wrist and impaired voluntary finger movements. These results are echoed by the clinical results for hemi paresis, spasticity and impaired fine motor function (grasp, release and manipulation of small objects). Importantly, the current maintenance of higher-order cognitive and sensory functions suggested that higher-order cortical networks were spared, allowing for active engagement in immersive VR and motor imagery training.

Therefore, the radiographic findings provided both anatomic confirmation and informed the therapeutic rationale. The rehab program targeted the remaining cortical pathways and aimed to induce functional recovery in the subacute stage of stroke when there is a high potential for neuroplasticity, with a focus on visuo-proprioceptive illusion, tendon vibration, and motor imagery.



Outcome	Baseline	3 Weeks	6 Weeks
FMA-UE	30	43	56
NHPT (s)	102	71	48
BBT	16	29	43
Tip Pinch (kg)	1.3	2.7	4.5
Lateral Pinch (kg)	2.0	3.9	5.8
Three-Jaw Chuck Pinch (kg)	1.6	3.2	5.0
MTS Wrist Flexors (X score)	2	1	1
MTS Finger Flexors (X score)	3	2	1



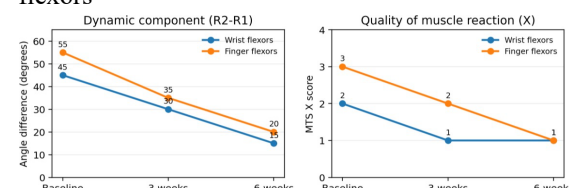
The results revealed a progressive and obvious improvement in motor coordination of the upper limb, hand dexterity, pinch strength and muscle tone during the 6-week assessment period. The Fugl-Meyer Assessment for Upper Extremity (FMA-UE) score significantly improved from baseline to 3 weeks (30 to 43) and 6 weeks (56), showing a significant improvement in motor recovery and functional movement of the affected upper limb. Likewise, the Nine Hole Peg Test (NHPT) was used to assess performance and was found to be better at 3 weeks (102 to 71s) and 6 weeks (102 to 48s). The results suggested that there was progressive [10,12]

Improvement in fine motor coordination and hand function as a lower completion time meant better manual dexterity. The Box and Block Test (BBT) score also rose from 16 blocks at baseline to 29 blocks at 3 weeks and 43 blocks at 6 weeks, showed improvement in gross manual dexterity (manipulating objects with both hands) and the ability to repeat grasp-releases and releases more efficiently. [10,12]

All measures of pinch strength also showed

significant improvement. The tip pinch strength was increased at 3 and 6 weeks from the base line value of 1.3 kg to 2.7 kg and 4.5 kg, respectively, and the lateral pinch strength was increased at 3 and 6 weeks from the base line value of 2.0 kg to 3.9 kg and 5.8 kg, respectively. Likewise, the three-jaw chuck pinch strength rose from 1.6 kg at baseline to 3.2 kg at 3-week and 5.0 kg at 6-week interventions. These improvements signify improved intrinsic and extrinsic muscle strength of the hand, which aids in grasping, holding and manipulating objects. On the contrary, there was a decrease in muscle tone on the Modified Tardieu Scale (MTS) scores. Wrist flexor scores went down from 2 to 1, and finger flexor scores went down from 3 to 2 then to 1 over the period of the intervention, indicating a decrease in spasticity during the intervention. Overall, the improvements in all functional and strength-related outcomes were consistent and reductions in muscle tone suggested that there was meaningful upper extremity functional recovery associated with the intervention over 6 weeks.

Muscle Group	MTS Variable	Baseline	3 Weeks	6 Weeks
Wrist flexors	R1 (degrees)	10	30	50
Wrist flexors	R2 (degrees)	55	60	65
Wrist flexors	R2-R1 (degrees)	45	30	15
Wrist flexors	X score	2	1	1
Finger flexors	R1 (degrees)	15	40	60
Finger flexors	R2 (degrees)	70	75	80
Finger flexors	R2-R1 (degrees)	55	35	20
Finger flexors	X score	3	2	1



The findings of the Modified Tardieu Scale (MTS) : both the wrist flexor and finger flexor muscles showed a progressive improvement in flexibility and decrease in spasticity over the 6-week period. There was a progressive increase in the fast velocity range of motion of the wrist flexor muscle

with R1 values at 10° at baseline, 30° at 3 weeks, and 50° at 6 weeks. Concurrently, the R2 value, which represents the available passive range of motion when the muscle was stretched slowly, increased from 55° at baseline to 60° at 3 weeks and 65° at 6 weeks, indicating improvement in available passive range of motion with slow stretch. Importantly, the difference between R2 and R1 became significantly smaller at 3 weeks from 45° at baseline, and at 6 weeks from 15° at baseline. This decrease represented a decrease in the dynamic component of muscle spasticity and better muscle lengthening. The X score also increased from 2 at baseline to 1 at 3 weeks, and stayed at 1 at 6 weeks, indicated a decrease in the muscle response to stretch.

The same was observed for the flexors of the fingers over the six weeks. The R1 value at 3 weeks was 40° and at 6 weeks was 60° compared with a baseline of 15° which represented a significant improvement in fast velocity movement. The R2 value was also greater at 3 and 6 weeks (70° and 75°), reflected increased passive range of motion. At 3 and 6 weeks, there was a large drop in the R2–R1 difference, from 55° at baseline to 35° and 20°, respectively, indicated a significant decrease in the dynamic limitation due to spasticity. In addition, at 3 and 6 weeks, the X score was 2 and 1, respectively, suggested a progressive improvement in muscle reaction to stretch. In general, the results indicated that there was a gradual decrease in spasticity, increase in range of motion and increase in muscle extensibility in both flexor wrist and flexor finger groups, with the most significant functional improvement noted after 6 weeks.

Discussion

Our results showed that the multimodal rehabilitation program using IVR, motor imagery, and tendon vibration in addition to conventional physiotherapy can be very helpful when used for upper limb rehabilitation in subacute stroke patients. Within six weeks the patient showed significant gains in motor control, dexterity, and pinch strength and spasticity reduction. The Fugl-Meyer Assessment–Upper Extremity score improved from 30 to 56, the Nine Hole Peg Test times improved from 102 to 48 seconds, and the Box and Block Test score increased from 16 to 43 blocks per minute. Pinch strengths showed significant improvement and Modified Tardieu Scale scores showed a decrease in spasticity of wrist and finger flexors. The findings indicated that the intervention not only enhanced voluntary motor function but also acted on hypertonia, which is a double challenge in stroke rehabilitation. [3,11]

These improvements can be understood in the light of the synergy of the three modalities. When tendon vibration was synchronized with the hand

movements in the VR system, the illusion of the hand in the VR system was congruent with the sensation generated by the tendon vibration, thus reinforcing the motor representations and minimizing the maladaptive reorganization of the cortex. Motor imagery activated motor cortical areas without any actual movement, and thus reinforced the corticospinal pathways and prepared the brain to control the voluntary execution. Muscle spindle afferents were stimulated by tendon vibration at 100 Hz to increase proprioceptive input and decrease reflex hyper excitability, which resulted in a decrease in spasticity. Lastly, VR was used to create immersive environments that were enhanced and varied in difficulty, which encouraged repetition and motor learning, while maintaining a sense of motivation. Combined these mechanisms are likely to have been responsible for further enhancement of neuroplasticity during the subacute period when the reorganization of the cortex is most susceptible. [4] [2] [6–8]

The novelty of this study is the combination of VR, MI and TV. Each modality has shown to be effective on an individual basis; VR has been associated with improvements in motor function and engagement; MI has been associated with improvements in recovery using cognitive rehearsal; and TV has been associated with reductions in spasticity through modulation of the proprioceptive feedback. But there are few studies that combine these modalities. This case study provides additional evidence of their integration yielding better results, indicating the possibility of the effectiveness of multimodal interventions over single interventions. [6–8]

Comparison with Literature

Findings in Current Case

VR-based rehabilitation improves dexterity and independence	Patient showed improved NHPT and BBT scores, reflecting enhanced fine and gross motor dexterity.
Motor imagery strengthens corticospinal pathways	Patient demonstrated improved pinch strength and voluntary motor control.
Tendon vibration reduces spasticity and enhances motor control	Patient's MTS scores decreased, indicating reduced spasticity in wrist and finger flexors.
Combined application: synergistic effects	This case shows synergistic effects, with improvements across all functional domains.

The advantages of this study are the use of the multi-modal approach, objective outcome measures, progressive protocol design, and high engagement of patients. VR/MI/TV simultaneously engaged multiple neural pathways,

and the use of standard assessments allowed for objective measurement of the results. The difficulty of the VR tasks were designed to be adaptive to maintain challenge for motor learning, and VR's immersive experience could have motivated and increased adherence. [6,7,8] [11,12] However, restrictions are to be noted. Because of the single case design, the results should not be generalized, and since no control group was included, the individual contributions of each modality cannot be determined. Short-term follow up does not provide a complete picture of long-term sustainability, and the ability of the patient to have their cognition and motivation intact may not be reflective of all stroke survivors. In addition, high-tech VR gear might not be available in low-resource environments, making scalability an issue.

Randomized controlled trials with larger numbers of participants should be conducted to confirm these results in the future. Improvements must be followed up for a long time in order to see if they were sustainable. Mechanistic insights into cortical changes underlying recovery might be gained by neuroimaging studies. There may be cost effectiveness analyses needed for clinical uptake and personalized protocols optimized to individual deficits. Larger number of studies, with a wider range of patients that include more cognitively and motivationally diverse patients will improve generalizability.

Finally, this case study provides an example of how the use of immersive VR, motor imagery and tendon vibration can be integrated with traditional physiotherapy to improve the rehabilitation of the upper limb in subacute stroke patients and reduce spasticity. After 6 weeks, the intervention was associated with significant improvements in motor function, dexterity, and pinch strength and muscle tone. These three factors of the visuo-proprioceptive illusion, cognitive rehearsal and proprioceptive stimulation may have enhanced neuroplasticity within the critical recovery window, in a mechanistic sense. Despite its potential, more studies are needed to prove its efficacy, scalability, and clinical integration.



Conclusion

This case study highlights the potential for combining immersive VR, MI, and tendon vibration with standard physiotherapy in sub-acute

stroke rehabilitation. This multimodal treatment proved effective in that the patient showed substantial improvement in motor control, motor dexterity, pinch strength, and spasticity reduction within 6 wks. The Fugl-Meyer Assessment–Upper Extremity score improved from 30 to 56, the Nine Hole Peg Test improved from 102 to 48 seconds and Box and Block Test improved from 16 to 43 blocks per minute. These results showed that the treatment was effective not only to improve voluntary motor function, but also to reduce hyper tonicity—two important issues in stroke recovery.

The synergy of visuo-proprioceptive illusion, motor imagery, and tendon vibration, may have enhanced the neuroplasticity during the subacute phase, when the reorganization is more prominent, mechanically. The visuo-proprioceptive illusion gave congruent sensory input, leading to less maladaptive cortical changes and reinforcement of motor representations. Motor imagery activated motor cortical areas without overt motion to enhance corticospinal function and prepare the brain for voluntary movement. Proprioceptive input (stimulation of the tendon at 100Hz) decreased reflex hyper excitability and decreased spasticity. These modalities formed a holistic rehabilitation space that optimized the rehabilitation potential.

The advantages of this study are that it is multimodal, has objective outcome measures, and is highly engaged with the patient. The adaptable difficulty of VR tasks ensured an ongoing challenge and motivation to those working, and standardized testing assessments worked well as a way to reliably quantify progress. Some limitations, however, are recognized such as being a single case design, no control group, and short follow-up. This limits the generalizability and the sustainability and scalability of the intervention, especially in resource-limited environments.

Overall, the presented case study shows that using immersive VR, motor imagery and tendon vibration in addition to traditional physiotherapy can speed up the functional recovery and decrease spasticity in subacute stroke patients. The results indicate that multimodal interventions could be a better and comprehensive treatment for stroke rehabilitation, but more research needs to be done with larger number of patients and longer follow-up periods. This novel approach has the potential to improve patient outcomes and contribute to clinical practice in neurorehabilitation.

References

1. Winstein CJ, Stein J, Arena R, Bates B, Cherney LR, Cramer SC, et al. Guidelines for Adult Stroke Rehabilitation and Recovery: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke*.

- 2016;47:e98-e169.
doi:10.1161/STR.0000000000000098.
2. Guerra ZF, Lucchetti ALG, Lucchetti G. Motor imagery training after stroke: A systematic review and meta-analysis of randomized controlled trials. *J Neurol Phys Ther.* 2017;41(4):205-214. doi:10.1097/NPT.0000000000000200.
3. Lundquist CB, Maribo T. The Fugl-Meyer assessment of the upper extremity: reliability, responsiveness and validity of the Danish version. *Disabil Rehabil.* 2017;39(9):934-939. doi:10.3109/09638288.2016.1163422.
4. Mortaza N, Abou-Setta AM, Zarychanski R, Loewen H, Rabbani R, Glazebrook CM. Upper limb tendon/muscle vibration in persons with subacute and chronic stroke: a systematic review and meta-analysis. *Eur J Phys Rehabil Med.* 2019;55(5):558-569. doi:10.23736/S1973-9087.19.05605-3.
5. Ekstrand E, Lexell J, Brogårdh C. Test-retest reliability and convergent validity of three manual dexterity measures in persons with chronic stroke. *PM R.* 2016;8(10):935-943. doi:10.1016/j.pmrj.2016.02.014.
6. Chen J, Or CK, Chen T. Effectiveness of using virtual reality-supported exercise therapy for upper extremity motor rehabilitation in patients with stroke: systematic review and meta-analysis of randomized controlled trials. *J Med Internet Res.* 2022;24(6):e24111. doi:10.2196/24111.
7. Hao J, He Z, Yu X, Remis A. Comparison of immersive and non-immersive virtual reality for upper extremity functional recovery in patients with stroke: a systematic review and network meta-analysis. *Neurol Sci.* 2023;44(8):2679-2697. doi:10.1007/s10072-023-06742-
8. Kiper P, Godart N, Cavalier M, Berard C, Cieřlik B, Federico S, et al. Effects of immersive virtual reality on upper-extremity stroke rehabilitation: a systematic review with meta-analysis. *J Clin Med.* 2024;13(1):146. doi:10.3390/jcm13010146.
9. Khan A, Podlasek A, Somaa F. Virtual reality in post-stroke neurorehabilitation: a systematic review and meta-analysis. *Top Stroke Rehabil.* 2023;30(1):53-72. doi:10.1080/10749357.2021.1990468.
10. Duncan Millar J, van Wijck F, Pollock A, Ali M. International consensus recommendations for outcome measurement in post-stroke arm rehabilitation trials. *Eur J Phys Rehabil Med.* 2021;57(1):61-68. doi:10.23736/S1973-9087.20.06575-2.
11. Wiesner S, Schwarz C, Meya U, Kaufmann J, Traenka C, Luft AR, et al. Interrater reliability of the Fugl-Meyer Motor assessment in stroke patients: a quality management project within the ESTREL study. 2024. PMID:38651097.
12. Prasomsri J, Sakai K, Ikeda Y. Effectiveness of Motor Imagery on Physical Function in Patients With Stroke: A Systematic Review. *Motor Control.* 2024;28(4):442-463. doi:10.1123/mc.2023-0045.
13. Kenea CD, Abessa TG, Lamba D, Bonnechère B. Immersive Virtual Reality in Stroke Rehabilitation: A Systematic Review and Meta-Analysis of Its Efficacy in Upper Limb Recovery. *J Clin Med.* 2025;14(6):1783. doi:10.3390/jcm14061783.