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EFFECTS OF MOTOR IMAGERY TECHNIQUE WITH AND WITHOUT VIRTUAL REALITY ON PAIN INTENSITY, FUNCTIONAL DISABILITY AND QUALITY OF LIFE IN PATIENT WITH POST STROKE SHOULDER HAND SYNDROME

Original Research (ID: 1690)

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ABSTRACT

Background: Stroke commonly results in long-term upper limb impairment, and post-stroke Shoulder–Hand Syndrome is one of the painful complications that can restrict movement, reduce independence, and negatively affect quality of life. Pain and stiffness often limit active participation in conventional rehabilitation. Motor imagery offers a non-invasive method of stimulating motor networks without physical strain, while virtual reality may enhance this effect through visual feedback, patient engagement, and sensory-motor integration.

Objective: To compare the effects of motor imagery with and without virtual reality on pain intensity, functional disability, and quality of life in patients with post-stroke Shoulder–Hand Syndrome.

Methods: A randomized controlled trial was conducted on 40 patients with post-stroke Shoulder–Hand Syndrome. Participants were allocated into two equal groups. Group A received motor imagery combined with virtual reality, while Group B received motor imagery alone. Both groups received 30-minute sessions, three days per week, for six weeks. Pain intensity was assessed using the Numeric Pain Rating Scale, functional disability through the Shoulder Pain and Disability Index, and quality of life through the Stroke-Specific Quality of Life Scale. Data were analyzed using SPSS version 25, and appropriate parametric or non-parametric tests were applied according to data distribution.

Results: Both groups showed significant improvement after intervention. The Numeric Pain Rating Scale score decreased from 6.95 ± 0.76 to 4.10 ± 0.79 in the motor imagery group and from 6.95 ± 0.76 to 2.00 ± 0.73 in the motor imagery with virtual reality group. SPADI total score decreased from 68.91 ± 4.49 to 49.91 ± 3.95 in the motor imagery group and from 69.15 ± 4.51 to 29.16 ± 3.29 in the combined group. SS-QoL score increased from 2.77 ± 0.10 to 3.30 ± 0.10 in the motor imagery group and from 2.77 ± 0.10 to 4.19 ± 0.09 in the combined group. Post-treatment between-group differences were statistically significant for all outcomes.

Conclusion: Motor imagery with and without virtual reality improved pain, disability, and quality of life in patients with post-stroke Shoulder–Hand Syndrome. However, virtual reality-assisted motor imagery produced greater clinical improvement and may be considered a valuable adjunct in neurorehabilitation.

Keywords: Activities of Daily Living; Complex Regional Pain Syndromes; Motor Imagery; Pain Measurement; Quality of Life; Stroke; Virtual Reality.

INTRODUCTION

Stroke remains one of the leading causes of long-term neurological disability and is frequently followed by persistent impairments in movement, sensation, coordination, and participation in daily life. Although survival after stroke has improved in many settings, a large proportion of stroke survivors continue to experience upper limb dysfunction, which limits independence in essential activities such as dressing, grooming, feeding, reaching, grasping, and personal care (1). Among the painful upper limb complications that may occur after stroke, Shoulder–Hand Syndrome is particularly disabling because it affects not only physical movement but also comfort, confidence, emotional well-being, and overall rehabilitation participation. Shoulder–Hand Syndrome, also recognized as post-stroke Complex Regional Pain Syndrome Type I, is commonly characterized by shoulder pain, hand swelling, stiffness, reduced range of motion, sensory disturbance, and progressive functional limitation. It usually develops within the early months after stroke and may affect a considerable proportion of stroke survivors if not identified and managed appropriately (2). The condition can create a difficult cycle in which pain discourages movement, reduced movement increases stiffness and weakness, and worsening disability further reduces the patient's willingness to use the affected limb. This cycle may delay recovery, increase dependency on caregivers, and negatively influence quality of life.

The development of Shoulder–Hand Syndrome is not limited to local musculoskeletal changes alone. Post-stroke disruption of sensory-motor pathways, altered cortical processing, impaired motor planning, autonomic disturbance, and abnormal pain modulation may all contribute to its clinical presentation (3). Maladaptive cortical reorganization and learned non-use behavior may further increase pain sensitivity and reduce voluntary use of the affected upper limb (4). As patients become fearful of pain during movement, they may avoid active participation in rehabilitation, which can result in progressive loss of mobility, function, and confidence. Therefore, effective rehabilitation should address both the physical limitations of the limb and the altered neurophysiological mechanisms involved in pain and motor recovery. Conventional physiotherapy approaches such as range of motion exercises, stretching, strengthening, manual therapy, positioning, and task-oriented training remain important components of post-stroke rehabilitation. However, these interventions may be difficult to perform when patients experience marked pain, swelling, stiffness, or fear of movement. In such cases, physically demanding therapy may be poorly tolerated, and patient adherence may decline. This limitation has encouraged growing interest in neurocognitive and brain-based rehabilitation strategies that can stimulate motor networks, support cortical plasticity, and encourage recovery without placing excessive physical stress on the painful limb.

Motor imagery is one such technique that has gained increasing attention in neurological rehabilitation. It involves the mental rehearsal of a movement without actual physical execution. During motor imagery, patients imagine performing specific movements of the affected limb in a controlled and purposeful manner while remaining physically relaxed. Neurophysiological evidence suggests that imagined movement activates several brain regions that are also involved in actual movement, including the premotor cortex, supplementary motor area, primary motor cortex, parietal regions, and cerebellum (5). Through repeated mental practice, motor imagery may help strengthen motor planning, improve sensory-motor integration, reduce learned non-use, and support functional recovery after stroke. Motor imagery may also have a meaningful role in pain modulation. By improving attention toward controlled movement, reducing sensory mismatch, and enhancing cortical organization, motor imagery can potentially reduce abnormal pain processing in patients with post-stroke upper limb complications (6). It is non-invasive, low-cost, safe, and practical, especially for patients who cannot tolerate intensive physical movement due to pain or restricted mobility. These qualities make it a clinically valuable option for individuals with Shoulder–Hand Syndrome, where pain and fear of movement often limit participation in active rehabilitation.

Virtual reality has also emerged as an important adjunct in modern neurorehabilitation. It provides an interactive, visually engaging, and feedback-rich environment that can simulate functional movements and encourage patient participation. Depending on the system used, virtual reality may be immersive, semi-immersive, or non-immersive, but its central therapeutic value lies in providing meaningful visual and sensory feedback during rehabilitation tasks (7). This feedback can improve motivation, attention, body awareness, spatial orientation, and movement accuracy, all of which are commonly affected after stroke. When virtual reality is combined with motor imagery, it may enhance the therapeutic effects of mental practice by making imagined movements more vivid, structured, and engaging. Visual simulation may help patients feel more connected to the intended movement, activate mirror neuron pathways, and improve sensory-motor reintegration (8). This is particularly relevant for patients with Shoulder–Hand Syndrome, as they often struggle to move the affected limb due to pain but may still benefit from visualized and imagined movement experiences. Virtual reality may also reduce fear of movement by shifting attention away from pain and increasing confidence through a safe, controlled, and motivating rehabilitation environment.

Previous studies have reported beneficial effects of motor imagery on pain reduction, voluntary motor control, and upper limb recovery after stroke, while virtual reality-based rehabilitation has been associated with improved motor performance, engagement, emotional well-being, and quality of life (9,10). However, most available studies have focused on general post-stroke upper limb dysfunction rather than specifically examining patients with Shoulder–Hand Syndrome. This distinction is important because Shoulder–Hand Syndrome includes a complex combination of pain, swelling, stiffness, sensory changes, autonomic disturbance, and functional disability. Therefore, findings from general stroke rehabilitation studies may not fully explain which intervention is more effective for this specific patient population. Despite the growing clinical interest in both interventions, there remains limited comparative evidence on whether motor imagery supported by virtual reality produces greater improvement than motor imagery alone in patients with post-stroke Shoulder–Hand Syndrome. This creates an important research gap for physiotherapists and rehabilitation professionals who need evidence-based, patient-friendly, and clinically feasible strategies to reduce pain, improve function, and enhance quality of life. The central research question is whether the addition of virtual reality to motor imagery provides superior outcomes in pain intensity, functional disability, and quality of life compared with motor imagery without virtual reality.

Therefore, the present study was designed to compare the effects of motor imagery technique with and without virtual reality on pain intensity, functional disability, and quality of life in patients with post-stroke Shoulder–Hand Syndrome. By addressing this comparison, the study aims to clarify whether virtual reality can enhance the therapeutic value of motor imagery and provide a more effective neurorehabilitation approach for improving recovery, participation, and daily functioning in this patient population.

METHODS

This randomized controlled trial was conducted in the Rehabilitation Department of Sukoon Rehab Center and Physiotherapy Clinic over a period of nine months after approval of the synopsis. The trial was registered under the clinical trial registration number NCT07610889, with Muhammad Hammad Khan listed in relation to the registration details. The study was designed to compare the therapeutic effects of motor imagery technique with virtual reality and motor imagery technique without virtual reality on pain intensity, functional disability, and quality of life among patients with post-stroke Shoulder–Hand Syndrome. The sample size was calculated using Epitool software on the basis of the Shoulder Pain and Disability Index, using previously reported mean and variance values from related literature (11). The calculated sample size was 36 participants, with 18 participants required in each group. After considering a 10% attrition rate, the final sample size was increased to 40 participants, with 20 participants allocated to each intervention group. A total of 45 patients were initially assessed for eligibility. Five participants were excluded, of whom three did not meet the inclusion criteria and two declined participation. Therefore, 40 eligible participants were enrolled and randomly allocated into two equal groups. Group A received motor imagery training with virtual reality, while Group B received motor imagery training without virtual reality. All enrolled participants completed the allocated intervention, and no participant was lost to follow-up or excluded from final analysis.

Participants were recruited through a non-probability purposive sampling technique and were then randomly assigned into the two treatment groups. Eligible participants included male and female post-stroke patients aged 40 to 70 years who had been clinically diagnosed with stage I or II Shoulder–Hand Syndrome. Participants were included if the duration of stroke was at least three months and if they were able to understand and follow motor imagery instructions (12,13). Patients were excluded if they had cognitive impairment, defined as a Mini-Mental State Examination score of less than 24, severe visual deficits, psychiatric illness, uncontrolled medical conditions, or any change in pain medication during the study period (14). These criteria were used to ensure participant safety, improve treatment consistency, and reduce the influence of confounding factors on pain and functional outcomes. Data collection was initiated after obtaining ethical approval from the Ethical Review Committee of Green International University. Written informed consent was obtained from all participants after explaining the study purpose, procedures, duration, potential benefits, and voluntary nature of participation. Participants were informed that they could withdraw from the study at any stage without any penalty or effect on their routine care. Confidentiality was maintained by coding all collected data and removing personal identifiers. The data were stored in password-protected files and were accessible only to the principal investigator and supervisory team. The interventions were non-invasive and were delivered according to established rehabilitation principles; therefore, no major physical or psychological risk was expected.

Baseline assessment was performed before the start of intervention. Pain intensity was measured using the Numeric Pain Rating Scale, an 11-point scale ranging from 0 to 10, where 0 indicated no pain and 10 indicated the worst imaginable pain. Functional disability was assessed using the Shoulder Pain and Disability Index, which evaluates shoulder-related pain and difficulty during functional activities such as reaching, lifting, dressing, carrying objects, and performing routine upper limb tasks. Quality of life was measured using the Stroke Specific Quality of Life Scale, which assesses stroke-related impact across physical, emotional, social, functional, and participation-based domains. These tools were selected because they were clinically relevant to Shoulder–Hand Syndrome and suitable for evaluating changes in pain, disability, and post-stroke quality of life. The intervention was delivered over six weeks, with each participant receiving three treatment sessions per week. Each session lasted 30 minutes. The session structure was kept similar for both groups to ensure that any difference in outcome could be attributed to the mode of motor imagery delivery rather than variation in treatment duration or therapeutic content. Each session consisted of a three-minute preparation phase, a 25-minute motor imagery practice phase, and a two-minute cool-down phase.

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Participants in Group A received motor imagery training assisted by virtual reality. During the preparation phase, participants were seated comfortably and guided through relaxation and controlled breathing to improve attention and readiness for imagery practice. A virtual reality headset was then applied, and participants watched simulated upper limb movements such as shoulder elevation, forward reaching, grasping and releasing objects, rotational movements, overhead activities, and simple functional tasks. While viewing these movements, the therapist verbally guided the participant to imagine performing the same movements with the affected limb in a smooth, controlled, and pain-free manner. The virtual environment was used to improve the vividness of imagined movement, provide visual feedback, increase patient engagement, and stimulate sensory-motor pathways involved in upper limb recovery after stroke (15,16). The session ended with slow breathing and relaxation after removal of the headset. Participants in Group B received conventional motor imagery training without virtual reality. The preparation phase, session duration, movement sequence, therapist guidance, and therapeutic goals were kept the same as Group A. During the main imagery phase, the therapist used a structured verbal script to guide participants through the same upper limb movements, including shoulder elevation, reaching, grasping, releasing, rotational movement, and functional task practice. Participants were instructed to imagine each movement as clearly and calmly as possible without physically performing the movement. This approach was intended to activate motor planning areas of the brain, encourage cortical reorganization, reduce pain-related fear, and improve functional use of the affected upper limb (17). The session was completed with a two-minute cool-down period involving breathing control and mental relaxation.

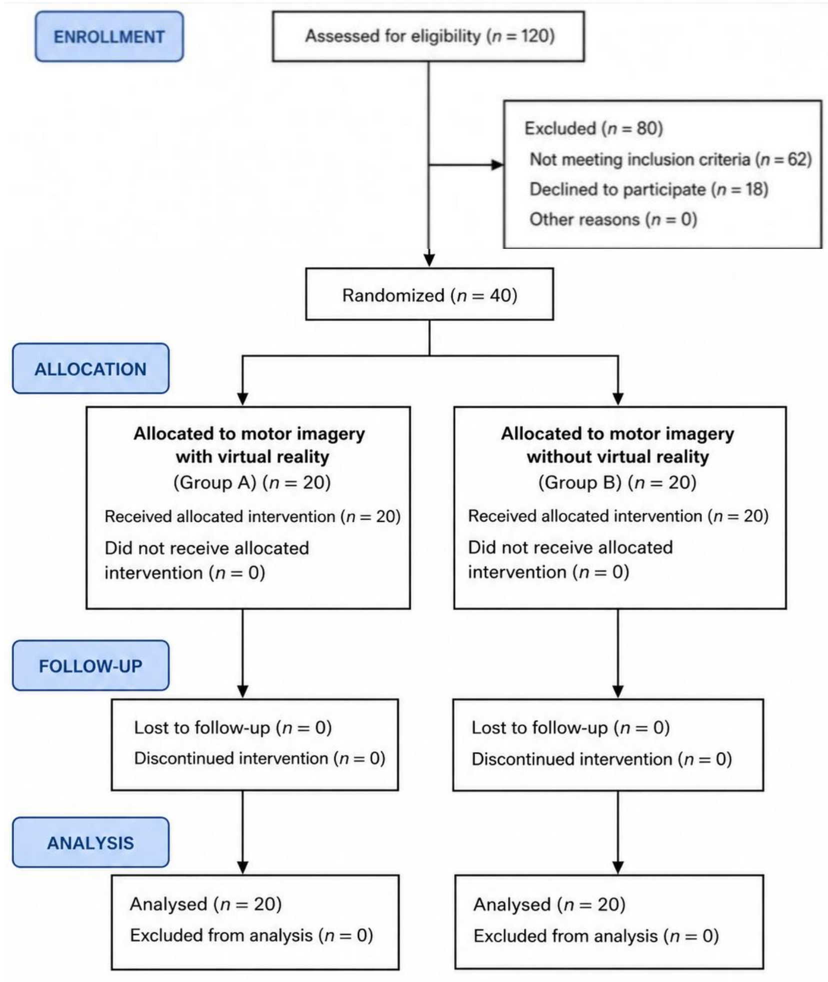


Figure 1. CONSORT Flow Diagram of Participant Recruitment and Allocation

Post-intervention assessment was performed immediately after completion of the six-week treatment protocol. The same outcome measures used at baseline were repeated after intervention, including the Numeric Pain Rating Scale, Shoulder Pain and Disability Index, and Stroke Specific Quality of Life Scale. All data were entered, coded, cleaned, and organized before statistical analysis. Data analysis was performed using the Statistical Package for Social Sciences version 25. Descriptive statistics were calculated for demographic and clinical variables. Mean and standard deviation were used for continuous variables, while frequency and percentage were used for categorical variables. The normality of data was assessed using the Shapiro–Wilk test or Kolmogorov–Smirnov test, as appropriate. For between-group comparison, the independent sample t-test was used for normally distributed data, while the Mann–Whitney U test was applied for non-normally distributed data. For within-group comparison from baseline to post-intervention, the paired sample t-test was used for normally distributed data, whereas the Wilcoxon signed-rank test was applied for non-normally distributed data. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 40 participants completed the study and were analyzed, with 20 participants in the motor imagery group and 20 participants in the motor imagery combined with virtual reality group. The gender distribution was identical in both groups, with 10 males (50.0%) and 10 females (50.0%) in each group. The mean age was 55.25 ± 5.77 years in the motor imagery group and 55.95 ± 5.57 years in the motor imagery combined with virtual reality group. The age range was 45–65 years in the motor imagery group and 46–65 years in the motor imagery combined with virtual reality group. Stroke duration was also equally distributed between the groups, with 1 participant

(5.0%) having a duration of 3 months, 9 participants (45.0%) having a duration of 3–6 months, 5 participants (25.0%) having a duration of 6–8 months, 4 participants (20.0%) having a duration of 8–12 months, and 1 participant (5.0%) having a duration of more than 1 year in each group. The affected side was similarly distributed, with 10 participants (50.0%) having right-sided involvement and 10 participants (50.0%) having left-sided involvement in each group. Normality testing was performed using the Shapiro–Wilk test. Several variables showed significant deviation from normal distribution. SPADI pain scores were non-normally distributed at both pre-treatment and post-treatment assessments in the motor imagery group (W = 0.874, p = 0.014; W = 0.865, p = 0.010) and in the motor imagery combined with virtual reality group (W = 0.828, p = 0.002; W = 0.830, p = 0.002). NPRS scores were also non-normally distributed before and after treatment in both groups, with values of W = 0.816, p = 0.002 and W = 0.809, p = 0.001 in the motor imagery group, and W = 0.816, p = 0.002 and W = 0.815, p = 0.001 in the motor imagery combined with virtual reality group. SPADI disability scores were normally distributed at pre-treatment and post-treatment assessments in both groups, while SPADI total and SS-QoL scores showed mixed normality findings. Because normality was not consistently met across the main outcome variables, non-parametric analysis was applied.

At baseline, both groups were comparable across all outcome measures, with no statistically significant difference reported between the groups (p > 0.05). The mean SPADI pain score was 33.35 ± 2.13 in the motor imagery group and 33.50 ± 2.12 in the motor imagery combined with virtual reality group. The mean SPADI disability score was 56.40 ± 3.82 in both groups. The mean SPADI total score was 68.91 ± 4.49 in the motor imagery group and 69.15 ± 4.51 in the motor imagery combined with virtual reality group. The mean NPRS score was 6.95 ± 0.76 in both groups, while the mean SS-QoL score was 2.77 ± 0.10 in both groups. After the intervention, statistically significant between-group differences were observed across all outcome measures (p < 0.001). The mean SPADI pain score decreased to 23.45 ± 2.16 in the motor imagery group and to 12.75 ± 1.71 in the motor imagery combined with virtual reality group. The mean SPADI disability score decreased to 41.40 ± 2.99 in the motor imagery group and to 24.95 ± 2.50 in the motor imagery combined with virtual reality group. The mean SPADI total score decreased to 49.91 ± 3.95 and 29.16 ± 3.29, respectively. The mean NPRS score reduced to 4.10 ± 0.79 in the motor imagery group and to 2.00 ± 0.73 in the motor imagery combined with virtual reality group. The mean SS-QoL score increased to 3.30 ± 0.10 in the motor imagery group and to 4.19 ± 0.09 in the motor imagery combined with virtual reality group.

Within-group analysis showed statistically significant improvement in the motor imagery group for all measured outcomes after treatment (p < 0.001). The mean SPADI pain score decreased from 33.35 ± 2.13 to 23.45 ± 2.16, with a mean reduction of 9.90 points. The mean SPADI disability score decreased from 56.40 ± 3.82 to 41.40 ± 2.99, showing a mean reduction of 15.00 points. The mean SPADI total score decreased from 68.91 ± 4.49 to 49.91 ± 3.95, with a mean reduction of 19.00 points. The mean NPRS score decreased from 6.95 ± 0.76 to 4.10 ± 0.79, showing a mean reduction of 2.85 points. The mean SS-QoL score increased from 2.77 ± 0.10 to 3.30 ± 0.10, with a mean improvement of 0.53 points. The Wilcoxon signed-rank test showed significant changes in SPADI pain (Z = -5.590, p < 0.001), SPADI disability (Z = -5.528, p < 0.001), SPADI total (Z = -5.516, p < 0.001), NPRS (Z = -5.637, p < 0.001), and SS-QoL (Z = -5.527, p < 0.001). Based on the available mean values, the motor imagery combined with virtual reality group showed larger numerical changes after treatment. SPADI pain decreased by 20.75 points, SPADI disability decreased by 31.45 points, SPADI total decreased by 39.99 points, NPRS decreased by 4.95 points, and SS-QoL increased by 1.42 points. In comparison, the motor imagery group showed reductions of 9.90 points in SPADI pain, 15.00 points in SPADI disability, 19.00 points in SPADI total, 2.85 points in NPRS, and an increase of 0.53 points in SS-QoL. The post-treatment between-group differences were statistically significant for pain intensity, functional disability, total shoulder pain and disability, and stroke-specific quality of life (p < 0.001).

Table 1. Baseline Demographic and Clinical Comparability of Study Groups

Variable	Motor Imagery (n = 20)	Motor Imagery + VR (n = 20)	Test applied	p-value
Age, years, mean ± SD	55.25 ± 5.77	55.95 ± 5.57	Independent t-test	0.698
Age range, years	45–65	46–65	—	—
Male, n (%)	10 (50.0%)	10 (50.0%)	Chi-square/Fisher exact	1.000
Female, n (%)	10 (50.0%)	10 (50.0%)		1.000
Stroke duration: 3 months, n (%)	1 (5.0%)	1 (5.0%)	Fisher exact/Chi-square	1.000
Stroke duration: 3–6 months, n (%)	9 (45.0%)	9 (45.0%)		1.000
Stroke duration: 6–8 months, n (%)	5 (25.0%)	5 (25.0%)		1.000
Stroke duration: 8–12 months, n (%)	4 (20.0%)	4 (20.0%)		1.000

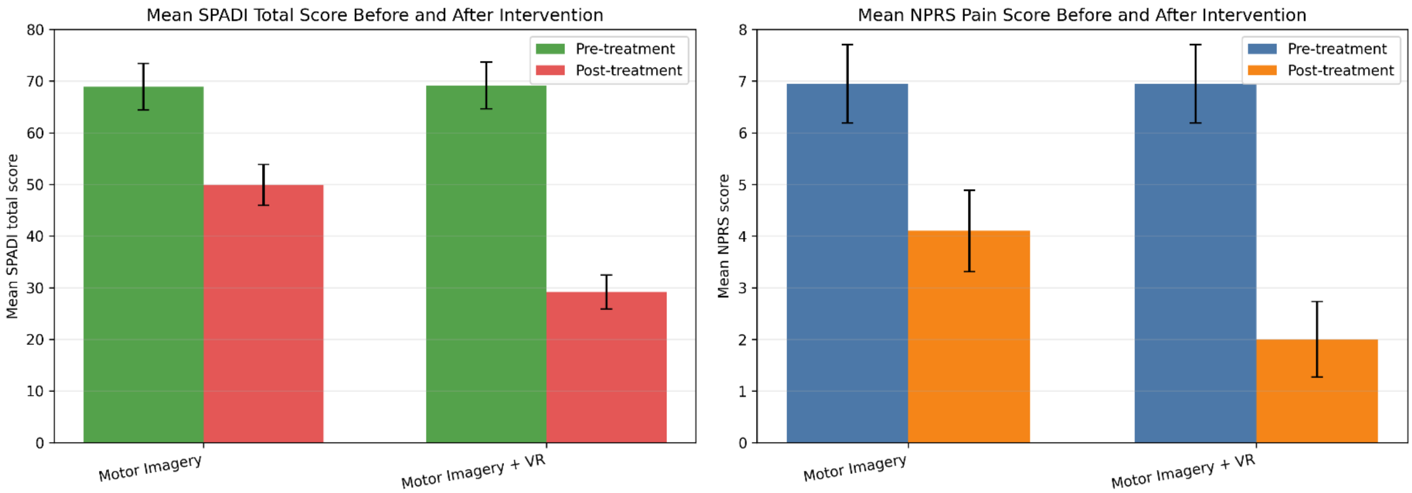
Stroke duration: >1 year, n (%)	1 (5.0%)	1 (5.0%)		1.000
Right affected side, n (%)	10 (50.0%)	10 (50.0%)	Chi-square/Fisher exact	1.000
Left affected side, n (%)	10 (50.0%)	10 (50.0%)		1.000

Table 2. Between-Group Comparison of Outcome Measures at Baseline and Post-Treatment

Outcome measure	**Assessment time**	**Motor Imagery Mean ± SD**	**Motor Imagery + VR Mean ± SD**	**Mean difference**	**95% CI of difference**	**p-value**	**Effect size**
SPADI pain	Baseline	33.35 ± 2.13	33.50 ± 2.12	-0.15	-1.51 to 1.21	0.825	0.07
SPADI pain	Post-treatment	23.45 ± 2.16	12.75 ± 1.71	10.70	9.45 to 11.95	<0.001	5.38
SPADI disability	Baseline	56.40 ± 3.82	56.40 ± 3.82	0.00	-2.45 to 2.45	1.000	0.00
SPADI disability	Post-treatment	41.40 ± 2.99	24.95 ± 2.50	16.45	14.68 to 18.22	<0.001	5.85
SPADI total	Baseline	68.91 ± 4.49	69.15 ± 4.51	-0.24	-3.12 to 2.64	0.867	0.05
SPADI total	Post-treatment	49.91 ± 3.95	29.16 ± 3.29	20.75	18.42 to 23.08	<0.001	5.59
NPRS	Baseline	6.95 ± 0.76	6.95 ± 0.76	0.00	-0.49 to 0.49	1.000	0.00
NPRS	Post-treatment	4.10 ± 0.79	2.00 ± 0.73	2.10	1.61 to 2.59	<0.001	2.71
SS-QoL	Baseline	2.77 ± 0.10	2.77 ± 0.10	0.00	-0.06 to 0.06	1.000	0.00
SS-QoL	Post-treatment	3.30 ± 0.10	4.19 ± 0.09	-0.89	-0.95 to -0.83	<0.001	9.17

Table 3. Magnitude of Improvement Within Each Group

Outcome measure	**Motor Imagery change**	**Motor Imagery improvement %**	**Motor Imagery + VR change**	**Motor Imagery + VR improvement %**	**Additional improvement with VR**
SPADI pain	9.90-point reduction	29.7%	20.75-point reduction	61.9%	10.85 points
SPADI disability	15.00-point reduction	26.6%	31.45-point reduction	55.8%	16.45 points
SPADI total	19.00-point reduction	27.6%	39.99-point reduction	57.8%	20.99 points
NPRS	2.85-point reduction	41.0%	4.95-point reduction	71.2%	2.10 points
SS-QoL	0.53-point increase	19.1%	1.42-point increase	51.3%	0.89 points



DISCUSSION

The present study compared the effects of motor imagery alone and motor imagery combined with virtual reality on pain intensity, functional disability, and quality of life in patients with post-stroke Shoulder–Hand Syndrome. The findings showed that both intervention groups improved after six weeks of treatment; however, greater improvement was observed in the motor imagery combined with virtual reality group across all measured outcomes. At baseline, both groups were comparable in demographic and clinical characteristics, as well as in pain, disability, and quality of life scores, which indicated reasonable group homogeneity before intervention. After treatment, the NPRS score decreased from 6.95 ± 0.76 to 4.10 ± 0.79 in the motor imagery group, while it decreased from 6.95 ± 0.76 to 2.00 ± 0.73 in the motor imagery combined with virtual reality group. Similarly, SPADI pain, disability, and total scores showed greater reduction in the combined intervention group. Quality of life also improved in both groups, but the increase was more pronounced in the motor imagery combined with virtual reality group, where the SS-QoL score increased from 2.77 ± 0.10 to 4.19 ± 0.09 compared with an increase from 2.77 ± 0.10 to 3.30 ± 0.10 in the motor imagery group. These findings suggested that motor imagery had a beneficial role in post-stroke rehabilitation, while the addition of virtual reality appeared to enhance its therapeutic effect through visual feedback, higher engagement, and enriched sensory-motor stimulation. Pain reduction was one of the most clinically relevant findings of this study because post-stroke shoulder pain frequently interferes with active rehabilitation, sleep, emotional well-being, and functional use of the affected upper limb. Both groups demonstrated a meaningful decrease in pain, but the reduction was larger in the motor imagery combined with virtual reality group. This finding was consistent with previous rehabilitation literature, which showed that motor imagery could activate neural networks involved in movement planning and execution, even without actual physical movement (2). Through repeated mental rehearsal, motor imagery may have supported cortical reorganization, improved motor control, reduced fear of movement, and decreased abnormal loading or guarding of the shoulder. A previous systematic review reported that mental practice had a positive effect on stroke rehabilitation outcomes, and another meta-analysis found that motor imagery improved upper-limb motor function in stroke survivors (3). Although these studies primarily focused on motor recovery, improved motor control may indirectly reduce pain by decreasing compensatory movement patterns, shoulder stiffness, and mechanical stress on painful tissues (18).

The greater reduction in pain in the motor imagery combined with virtual reality group may have been related to the additional visual and sensory feedback provided by virtual reality. A previous Cochrane review reported that virtual reality could improve upper-limb function and activity performance after stroke when compared with standard therapy (5). Virtual reality may have strengthened the effects of motor imagery by making imagined movement more vivid, externally guided, and easier for patients to follow. In patients with Shoulder–Hand Syndrome, pain is often influenced by both peripheral changes and altered central pain processing. Therefore, a combined intervention that stimulated motor planning, attention, visual feedback, and sensory-motor integration may have addressed pain through more than one mechanism (19). The marked reduction in NPRS score in the combined group supported the possibility that virtual reality enhanced pain modulation by reducing pain-focused attention, improving confidence, and allowing patients to mentally rehearse movement in a safe and controlled environment. Functional disability also improved significantly in both groups, with greater gains in the motor imagery combined with virtual reality group. This was an important finding because upper-limb disability after stroke directly affects independence in dressing, grooming, feeding, reaching, and other daily activities. The SPADI disability score decreased from 56.40 ± 3.82 to 41.40 ± 2.99 in the motor imagery group, while it decreased more substantially to 24.95 ± 2.50 in the combined group. The SPADI total score also showed a larger reduction in the combined group, decreasing from 69.15 ± 4.51 to 29.16 ± 3.29.

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These results suggested that both interventions helped reduce shoulder-related limitation, but virtual reality added a stronger functional benefit.

The functional improvement observed in the motor imagery group was supported by earlier evidence showing that mental practice activated cortical motor areas involved in movement preparation and execution (20). Previous trials had shown that structured motor imagery improved upper-limb performance, movement coordination, and functional recovery after stroke, particularly when it was used alongside conventional rehabilitation (21,22). The present findings were consistent with this evidence because the motor imagery group showed improvement in pain, disability, and quality of life after treatment. However, the larger functional gains in the motor imagery combined with virtual reality group suggested that internal mental rehearsal alone may not provide the same level of therapeutic stimulation as imagery supported by visual feedback. Virtual reality may have increased movement awareness, improved task orientation, enhanced motivation, and supported more accurate mental representation of the affected limb. Previous clinical studies also reported that virtual reality-based rehabilitation improved arm function, movement accuracy, and task performance among stroke survivors (23). Training in three-dimensional virtual environments had also been associated with improved motor recovery and better functional use of the upper limb (24). The improvement in quality of life further strengthened the clinical relevance of the findings. Post-stroke Shoulder–Hand Syndrome affects more than pain and movement; it also influences mood, confidence, self-care, social participation, and overall satisfaction with recovery. In the present study, quality of life improved in both groups, but the gain was greater in the motor imagery combined with virtual reality group. This improvement was likely related to the combined reduction in pain and functional disability. When patients experienced less pain and better upper-limb control, they were more likely to participate in daily activities and rehabilitation with greater confidence. Previous literature had shown that stroke-related quality of life was closely linked with physical independence, emotional status, participation, and functional performance (7,14). Therefore, the improvement in SS-QoL scores in this study appeared consistent with the broader understanding that rehabilitation strategies targeting both physical and psychological barriers may improve patient-centered outcomes.

The findings also supported the growing view that virtual reality may offer benefits beyond motor recovery alone. Earlier studies reported that virtual reality-based rehabilitation increased motivation, enjoyment, adherence, and emotional engagement during therapy (5,13). These factors are clinically important in stroke rehabilitation because recovery often requires repetitive practice over several weeks or months. Traditional exercises may become tiring or discouraging, particularly for patients with painful upper-limb conditions. In contrast, virtual reality may provide a more engaging rehabilitation environment that helps patients remain attentive and involved. However, these findings should be interpreted carefully. Although virtual reality appeared to enhance treatment outcomes in this study, its routine use may depend on equipment availability, cost, therapist training, patient tolerance, and clinical setting. Therefore, virtual reality should be considered a valuable adjunct rather than a replacement for therapist-guided rehabilitation (18, 25). The study had several strengths. The randomized controlled design strengthened the internal validity of the findings and allowed direct comparison between motor imagery alone and motor imagery combined with virtual reality. Both groups received the same treatment frequency, session duration, movement sequence, and therapeutic goals, while the only major difference was the addition of virtual reality. This improved the fairness of comparison and helped attribute post-treatment differences to the intervention approach. The use of standardized outcome measures, including NPRS, SPADI, and SS-QoL, also strengthened the clinical relevance of the results. These tools were appropriate for assessing pain intensity, shoulder-related disability, and stroke-specific quality of life. Another strength was the focus on post-stroke Shoulder–Hand Syndrome, a patient group that is clinically important but less frequently studied than general post-stroke upper-limb dysfunction. By addressing pain, disability, and quality of life together, the study provided a broader understanding of patient recovery rather than focusing only on motor performance.

Despite these strengths, several limitations were present. The sample size was relatively small, with 40 participants included in the final analysis, which limited the generalizability of the findings to the wider population of stroke survivors. Although the sample size was statistically calculated, larger studies would provide stronger evidence and more precise estimates of treatment effect. The study was conducted in a single clinical setting, which may have limited external validity because rehabilitation facilities differ in therapist expertise, available resources, patient characteristics, and service delivery models. The use of non-probability purposive sampling may also have introduced selection bias. In addition, the intervention lasted six weeks and did not include long-term follow-up, so it remained unclear whether the improvements in pain, disability, and quality of life were sustained after completion of treatment. Another important limitation was the inability to blind participants due to the nature of virtual reality intervention. This may have introduced performance bias, particularly because patients receiving virtual reality may have perceived their treatment as more advanced or engaging. The study also relied on patient-reported outcomes, including pain and quality of life measures, which may have been influenced by personal perception, expectation, mood, or response bias. The absence of objective neurophysiological measures, such as brain activation patterns, proprioceptive assessment, or kinematic movement analysis, limited the ability to explain the exact mechanisms behind the observed improvement. Adherence, home activity level, motivation, prior rehabilitation exposure, medication use, and therapist-patient interaction were also potential influencing factors that may not have been fully controlled. These limitations did not reduce the value of the findings, but they supported cautious interpretation and highlighted the need for further research.

Future research should include larger multi-center randomized controlled trials with longer follow-up periods to determine whether the benefits of virtual reality-assisted motor imagery were maintained over time. Future studies should also compare different types of virtual reality systems, including immersive, semi-immersive, and non-immersive platforms, to identify the most feasible and clinically effective approach. The optimal duration, frequency, intensity, and progression of motor imagery combined with virtual reality should also be examined. Inclusion of objective measures such as upper-limb kinematics, range of motion, grip strength, autonomic symptoms, functional task performance, and neurophysiological imaging would improve understanding of treatment mechanisms. Further studies should also evaluate cost-effectiveness, therapist training requirements, patient satisfaction, and clinical feasibility in low-resource rehabilitation settings. The clinical implications of this study were meaningful for physiotherapists and rehabilitation professionals working with patients who have post-stroke Shoulder–Hand Syndrome. Motor imagery alone appeared to be a practical, low-cost, non-invasive intervention that could be integrated into routine rehabilitation, especially for patients who were unable to perform active movement due to pain. The addition of virtual reality appeared to provide greater improvement in pain, functional disability, and quality of life, suggesting that technology-supported imagery may be useful for patients who require more engaging, feedback-based rehabilitation. The findings contributed to the growing evidence that combining cognitive rehabilitation strategies with interactive sensory feedback may provide a more comprehensive approach to post-stroke upper-limb recovery. Overall, the study suggested that virtual reality-assisted motor imagery was a promising adjunctive intervention for improving patient-centered outcomes in post-stroke Shoulder–Hand Syndrome, while further large-scale and long-term studies were needed before broad clinical recommendations could be made.

CONCLUSION

The study concluded that both motor imagery alone and motor imagery combined with virtual reality were effective rehabilitation approaches for improving pain, functional disability, and quality of life in patients with post-stroke Shoulder–Hand Syndrome. However, motor imagery supported by virtual reality produced greater overall improvement, suggesting that the addition of visual feedback, interactive engagement, and enhanced sensory-motor stimulation strengthened the therapeutic effects of motor imagery. These findings support the practical value of integrating virtual reality-assisted motor imagery into neurorehabilitation programs, particularly for patients whose shoulder pain and movement fear limit active participation in conventional therapy. Overall, the study highlighted virtual reality-assisted motor imagery as a promising, patient-centered, and clinically useful approach for improving recovery and daily functioning in individuals with post-stroke Shoulder–Hand Syndrome.

AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Hammad Khan	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Dr. Syeda Nida Fatima	Methodology, Investigation, Data Curation, Writing - Review & Editing
Prof Dr Fahad Tanveer	Investigation, Data Curation, Formal Analysis, Software
Dr. Izzah Ijaz Syed	Software, Validation, Writing - Original Draft
Dr. Sehrish Shahzad	Formal Analysis, Writing - Review & Editing
Akasha Khan	Writing - Review & Editing, Assistance with Data Curation

REFERENCES

1. Pandian S, Sharma RK, Dwivedi A. Synergy-based motor therapy for post-stroke hemiparetic subjects: A randomized controlled trial. Journal of Neurosciences in Rural Practice. 2025;16(1):84-92.

2. Braun SM, Beurskens AJ, Borm PJ, Schack T, Wade DT. The effects of mental practice in stroke rehabilitation: a systematic review. Archives of physical medicine and rehabilitation. 2006;87(6):842-52.

3. Wang C, Peng L, Hou Z-G, Li J, Zhang T, Zhao J. Quantitative assessment of upper-limb motor function for post-stroke rehabilitation based on motor synergy analysis and multi-modality fusion. IEEE Transactions on Neural Systems and Rehabilitation Engineering. 2020;28(4):943-52.

4. Ietswaart M, Johnston M, Dijkerman HC, Joice S, Scott CL, MacWalter RS, et al. Mental practice with motor imagery in stroke recovery: randomized controlled trial of efficacy. Brain. 2011;134(5):1373-86.

5. Laver KE, Lange B, George S, Deutsch JE, Saposnik G, Chapman M, et al. Virtual reality for stroke rehabilitation. Cochrane database of systematic reviews. 2025(6).

6. Birklein F. Complex regional pain syndrome. Journal of neurology. 2005;252(2):131-8.

7. 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(6):e98-e169.

8. Sharma N, Pomeroy VM, Baron J-C. Motor imagery: a backdoor to the motor system after stroke? Stroke. 2006;37(7):1941-52.

9. Page SJ, Levine P, Sisto SA, Johnston MV. Mental practice combined with physical practice for upper-limb motor deficit in subacute stroke. Physical therapy. 2001;81(8):1455-62.

10. Merians AS, Jack D, Boian R, Tremaine M, Burdea GC, Adamovich SV, et al. Virtual reality–augmented rehabilitation for patients following stroke. Physical therapy. 2002;82(9):898-915.

11. Subramanian S, Knaut LA, Beaudoin C, McFadyen BJ, Feldman AG, Levin MF. Virtual reality environments for post-stroke arm rehabilitation. Journal of neuroengineering and rehabilitation. 2007;4(1):20.

12. Broeren J, Rydmark M, Sunnerhagen KS. Virtual reality and haptics as a training device for movement rehabilitation after stroke: a single-case study. Archives of physical medicine and rehabilitation. 2004;85(8):1247-50.

13. Kleim JA, Jones TA. Principles of experience-dependent neural plasticity: implications for rehabilitation after brain damage. Journal of speech, language, and hearing research. 2008;51(1):S225-S39.

14. Williams LS, Weinberger M, Harris LE, Clark DO, Biller J. Development of a stroke-specific quality of life scale. Stroke. 1999;30(7):1362-9.

15. Birklein, F., Dimova, V., & Häuser, W. (2022). Complex regional pain syndrome. Nature Reviews Disease Primers, 8, 22. https://doi.org/10.1038/s41572-022-00361-0

16. Braun, S., Beurskens, A., Borm, P., Schack, T., & Wade, D. (2020). The effects of mental practice in stroke rehabilitation: A systematic review. Archives of Physical Medicine and Rehabilitation, 101(3), 245–259. https://doi.org/10.1016/j.apmr.2019.11.002 Hussain, M., Khan, S., & Ali, Z. (2022). Effects of guided motor imagery on pain and functional recovery in post stroke patients. Pakistan Journal of Medical Sciences, 38(2), 450–456.

17. Ietswaart, M., Johnston, M., Dijkerman, H., Scott, C., Joice, S., & Hamilton, S. (2021). Mental practice with motor imagery in stroke rehabilitation. Neuropsychological Rehabilitation, 31(6), 895–915. https://doi.org/10.1080/09602011.2019.1661340

18. Laver, K. E., Lange, B., George, S., Deutsch, J. E., Saposnik, G., & Crotty, M. (2021). Virtual reality for stroke rehabilitation. Cochrane Database of Systematic Reviews, 2021(11), CD008349. https://doi.org/10.1002/14651858.CD008349.pub3

19. Li, X., Zhang, Y., & Wang, Y. (2021). Virtual reality based therapy for upper limb rehabilitation after stroke: A meta analysis. Archives of Physical Medicine and Rehabilitation, 102(7), 1360–1370.

20. Merians, A. S., Jack, D., Boian, R., Tremaine, M., Burdea, G. C., Adamovich, S. V., Recce, M. and Poizner, H. (2002) 'Virtual reality–augmented rehabilitation for patients following stroke', Physical therapy, 82(9), pp. 898-915.

21. Page, S. J., Levine, P., Sisto, S. A. and Johnston, M. V. (2001) 'Mental practice combined with physical practice for upper-limb motor deficit in subacute stroke', Physical therapy, 81(8), pp. 1455-1462.

22. Sharma, N., Pomeroy, V. M. and Baron, J.-C. (2006) 'Motor imagery: a backdoor to the motor system after stroke?', Stroke, 37(7), pp. 1941-1952.

23. Subramanian, S., Knaut, L. A., Beaudoin, C., McFadyen, B. J., Feldman, A. G. and Levin, M. F. (2007) 'Virtual reality environments for post-stroke arm rehabilitation', Journal of neuroengineering and rehabilitation, 4(1), pp. 20.

24. Williams, L. S., et al. (2021). Reliability and validity of the Stroke Specific Quality of Life Scale. Stroke, 52(4), e164–e167.https://doi.org/10.1161/STROKEAHA.120.032123

25. Winstein, C., et al. (2020). Guidelines for adult stroke rehabilitation and recovery. Stroke, 51(4), e364–e367. https://doi.org/10.1161/STR.0000000000000375

