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Research Article

Comparative Effects of the Motor Relearning Program on Functional Recovery in Hemorrhagic versus Ischemic Stroke Survivors- A Cohort study

Arvind Kumar[1], Vivek Gupta[2]*,
Subia Hasan[3] and Dileep Kumar[4]

[1]Additional Professor (Physiotherapy), Department of Physical Medicine & Rehabilitation, King George's Medical University, Lucknow, UP, India.
[2]Assistant Professor (Physiotherapy), Faculty of Allied & Healthcare Sciences, King George's Medical University, Lucknow, UP, India.
[3]Vice Dean, Allied Health Sciences, Hind Institute of Medical Sciences, Lucknow, UP, India.
[4]Professor, Department of Physical Medicine & Rehabilitation, King George's Medical University, Lucknow, UP, India.

Article Info:

***Correspondence:**
Vivek Gupta,
Assistant Professor (Physiotherapy), Faculty of Allied and Healthcare Sciences, King George's Medical University, Lucknow, UP, India.
Email: vg82mpt@gmail.com

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Abstract

Background: Stroke is a major global health issue, affecting 15 million people annually, with 5 million deaths and another 5 million left permanently disabled. In India, incidence ranges from 84–262 per 100,000, driven by demographic and lifestyle changes. Both ischemic and hemorrhagic strokes differ in recovery, but motor impairments severely limit independence. The Motor Relearning Program (MRP), developed by Carr and Shepherd, focuses on task-specific practice, feedback, and real-life transfer of skills. This study aimed to compare MRP's effectiveness on functional recovery in ischemic versus hemorrhagic stroke survivors using the Motor Assessment Scale (MAS) and Free Functional Scale (FFS).

Methods: Based on Indian prevalence data (ischemic ~75%, hemorrhagic ~25%), the calculated sample size was ~72 per group (~144 total) using a 95% confidence level and a 10% margin of error. Accordingly, 144 patients were recruited (ischemic = 72; hemorrhagic = 72). Both groups received MRP interventions for four weeks. Outcomes were measured using MAS and FFS at baseline, week 1, week 2, week 3, and week 4.

Results: Both groups demonstrated significant improvements in MAS and FFS scores. Hemorrhagic stroke survivors showed greater gains compared to ischemic survivors, particularly from the second week onwards.

Conclusion: MRP is an effective rehabilitation strategy for both ischemic and hemorrhagic stroke survivors, with hemorrhagic patients demonstrating superior recovery patterns.

Keywords: Motor Relearning Program, Stroke, MAS, Free Functional Scale, Physiotherapy

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Introduction

Stroke is a major cause of death and disability worldwide and is the second leading cause of death and the third leading cause of disability worldwide [1]. The World Health Organization estimates that almost 15 million people suffer a stroke every year. Of these, 5 million die and another 5 million are left permanently disabled[1].
Incidence rates in India, as reported by the National Stroke Registry Program, range from 84–262 per 100,000 population, with increasing trends in both rural and urban populations[2].
An epidemiological study over 30 years found an increase of 51% in stroke in India, accounting for almost 10% of the global burden[3].
Stroke is generally classified into two types: ischemic and hemorrhagic. Ischemic strokes, caused by arterial occlusion, account for about 70-80% of cases, while hemorrhagic strokes, caused by vessel rupture, account for 20-30%[4].
The Motor Relearning Program (MRP) by Carr and Shepherd is focused on task-specific practice, analysis of key components, and transfer of training to real-life contexts[5]. As opposed to conventional physiotherapy that targets impairment reduction, MRP is designed to speed up recovery by leveraging neuroplasticity using active participation and feedback[6]. Systematic reviews and randomized controlled trials have consistently supported task-oriented rehabilitation as the foundation of modern stroke recovery. Task oriented approaches, such as the Motor Relearning Program (MRP), emphasize repetitive practice of purposeful activities, integration of feedback and skill transfer to real life situations. This is contrasted to traditional impairment-based physiotherapy which tends to focus on isolated muscle strengthening or range of motion exercises. In a number of randomized controlled trials, patients who received structured, task-specific training had superior outcomes in motor performance, functional independence, and quality of life than those who received conventional therapy.[7-14]. For instance, Higgins et al.[9] observed significant improvement in upper limb function when patients engaged in repetitive, goal-directed tasks versus generic exercises. Singha[10] found MRP more effective than proprioceptive neuromuscular facilitation in improving basic mobility in survivors of chronic stroke.
Bian et al.[11] further emphasized the adaptability of MRP when paired with simulated reality, demonstrating a faster recovery in subacute patients. Correspondingly, Park et al.[12] confirmed that task-specific training increased independence in activities of daily living and Kwakkel et al.[13] validated the inclusion of robotics into task-oriented paradigms.
In their evidence-based review, Langhorne et al.[14] concluded that task oriented rehabilitation consistently improves long term outcomes across various patient populations. Taken together, these studies highlight the principle that functional recovery is most effectively achieved when rehabilitation is tailored to the needs of everyday life. Systematic reviews of studies also reported similar results for the trials considered. O'Rourke and Edwards[7] report that MRP as a task-oriented intervention improved upper limb function compared to standard of care, whereas Pollock et al.[15] assert that interventions that are task-oriented lead to better outcomes in function with respect to the participant's ability to perform everyday tasks. The reviews established beyond reasonable doubt the efficacy of task-oriented interventions over the usual interventions. The burden of stroke is not only fatal but also crippling for the survivors. The most common effects of stroke are hemiplegia and imbalance which affects most survivors' activities and daily routines. This is why rehabilitation is a critical aspect of stroke management and recovery plan.[18]
Although the mortality rate in hemorrhagic strokes is initially higher, patients who have survived a hemorrhage can be expected to make a relatively better recovery after the hemorrhage has been removed than those who have survived an

infarction [24]. Despite the strength of this evidence, it should be noted that there are limited comparative studies of the effectiveness of interventions for ischemic and hemorrhagic strokes. The majority of trials and reviews consolidate outcomes across stroke survivors with different etiology, thereby masking potential differences in intervention response. Pathophysiologically, ischemic strokes are characterized by arterial occlusion resulting in infarction and irreversible loss of brain tissue function[4,20], while hemorrhagic strokes are caused by vessel rupture and compressed brain tissue that is often salvaged after hematoma resolution.[24] As a result, differences in responses to rehabilitation interventions, particularly task-oriented therapies such as MRP, are likely to exist, although the evidence on this topic remains limited to date.

The limited amount of evidence makes it difficult for clinicians to determine which approach to recommend for patients' rehabilitation. Hemorrhagic individuals tend to demonstrate more challenging cases on admission, but the tendency shows the opposite trend when the acute period is over. Ischemic patients, on the other hand, are likely to exhibit less severe deficits that steadily improve after stroke onset. It is hard to say whether task-oriented rehabilitation should be modified for these populations based on the available findings.

Therefore, the results of the systematic review and randomized control trials conducted so far indicate the usefulness of task-oriented rehabilitation interventions generally. However, there is a need for studies that investigate each stroke type's rehabilitation separately, as each patient's rehabilitation process should be individualized to improve the recovery outcomes of both hemorrhagic and ischemic stroke patients. The current study aims to contribute to this area of research by providing a comparison of MRP's effects on the motor function of patients who have suffered hemorrhagic and ischemic strokes and offering insight into the potential differences in the rehabilitation effects on the two groups.

Methods

Study Design: Prospective comparative cohort study.

Sample Size Calculation: The sample size was calculated using the formula $n = Z^2P(1-P)/d^2$, where Z = 1.96 for a 95% confidence level, P = 0.75 for ischemic stroke and 0.25 for hemorrhagic stroke based on Indian prevalence data, and d = 0.10 (10%). This yielded a minimum sample size of approximately 72 participants per group (144 in total).

Sample Size: A total of 144 patients were included: Group 1, ischemic stroke (n = 72); Group 2, hemorrhagic stroke (n = 72).

Inclusion and Exclusion Criteria: Participants were recruited from the Department of Physical Medicine and Rehabilitation, KGMU, Lucknow, between October 2025 and March 2026. Participants were grouped according to CT-confirmed stroke subtype, with no random allocation to stroke subtype. The two groups were matched for age and sex. All participants received the same Motor Relearning Program for 45–60 minutes, five days per week, for four weeks. Written informed consent was obtained before participation. Eligible participants had a first-ever stroke, CT-confirmed ischemic or hemorrhagic stroke, age ≥35 years, hemiplegia within one week of stroke onset, and an initial Glasgow Coma Scale (GCS) score ≥5 [2,4,14,16]. Patients with traumatic intracerebral hemorrhage, cerebellar, brainstem, or subarachnoid hemorrhage, severe cognitive dysfunction interfering with rehabilitation, or pre-existing disabilities affecting functional independence were excluded [2,4,14,17–19].

Setting: The study was conducted at the Department of Physical Medicine and Rehabilitation, King George's Medical University (KGMU), Lucknow, Uttar Pradesh, India, from October 2025 to March 2026. A total of 144 patients were included, with 72 patients in each group (ischemic and hemorrhagic stroke). Informed consent and baseline investigations were obtained before commencement of the intervention.

Intervention: Motor Relearning Program (Carr & Shepherd protocol).

All participants received rehabilitation based on the Motor Relearning Program (MRP), a task-oriented approach developed by Carr and Shepherd. The program emphasizes active participation, repetitive practice of meaningful tasks, and transfer of skills into real-life contexts. It is structured into four key stages:

Analysis of Task:

Each functional activity (e.g., sit-to-stand, walking, reaching, transfers) was broken down into essential components. Therapists observed performance, identified missing or impaired elements, and explained these to patients to enhance awareness.

Practice of Missing Components:

Patients practiced specific motor components that were deficient, such as trunk control, weight shifting, or hand placement. Therapists provided demonstration, verbal and visual feedback, and manual guidance to facilitate correct movement patterns.

Practice of Whole Task:

Once components were addressed, patients practiced the entire functional task repetitively in a goal-oriented manner. Emphasis was placed on problem-solving, self-correction, and active engagement rather than passive movement.

Transfer of Training:

Skills were reinforced in real-life contexts, such as ward activities, home routines, and community tasks. Caregivers and staff were involved to ensure continuity of practice outside therapy sessions.

Delivery and Duration:

Baseline data collected from all participants prior to the intervention after those sessions were conducted five days per week for four weeks, each lasting approximately 45–60 minutes.

Both ischemic and hemorrhagic groups received the same structured protocol, tailored to individual deficits. Progress was monitored weekly using the Motor Assessment Scale (MAS) and Free Functional Scale (FFS).

- **Outcome Measures:**
  - Motor Assessment Scale (MAS)[21]
  - Free Functional Scale (FFS)[22]
- **Statistical Analysis:**

Two-sample t-test with equal variance was applied to compare the mean scores of the Motor Assessment Scale (MAS) and Free Functional Scale (FFS) between the two groups. This test determines whether the observed differences in recovery trajectories are statistically significant. All analyses were performed using SPSS Statistics, Version 25.0 Software.

Results: A total of **144 patients** were recruited, divided equally into ischemic (n = 72) and hemorrhagic (n = 72) groups. Both groups were matched for age and sex distribution to minimize confounding.

Table1: Baseline data

Group	Mean Age (years)	Age Range	Males (n, %)	Females (n, %)
Ischemic (n=72)	56.8 ± 10.2	35–75	36 (50%)	36 (50%)
Hemorrhagic (n=72)	57.1 ± 9.7	35–75	36 (50%)	36 (50%)

Ischemic and hemorrhagic groups were randomly matched according to age and sex. The mean age was divided into two categories: 35-75 years old, which was included in the range of stroke patients' ages. The number of male and female patients was also equal (50%) in both groups. This was done to obtain comparable and reliable results with high accuracy and statistical significance. In this way, the influence of age and sex on the outcome of the study was minimized.

Table 2: Motor Assessment Scale (MAS) – Total Scores

Group	Baseline (0 wk.)	Week 1	Week 2	Week 3	Week 4	MAS Gain
Ischemic (n=72)	17.4 ± 9.8	26.1 ± 11.2	32.5 ± 10.9	38.2 ± 9.7	42.3 ± 8.9	24.9 ± 7.1
Hemorrhagic (n=72)	15.2 ± 9.6	25.0 ± 10.8	31.7 ± 9.5	39.1 ± 8.4	46.2 ± 7.0	31.0 ± 9.8

The presented data illustrate the process of motor skills improvement in patients with ischemic and hemorrhagic stroke following the Motor Relearning Program (MRP) therapy course during the four-week treatment. The final MRP evaluation results were obtained among 72 patients with ischemic and hemorrhagic stroke each, making the total number of participants equal 144. At baseline, the mean MAS score among ischemic patients was moderately higher (17.4±9.8) than among hemorrhagic patients (15.2±9.6).

During the four-week rehabilitation, both groups demonstrated consistent motor skill improvements week by week. Specifically, in the final assessment, hemorrhagic patients improved the mean MAS score by 31.0±9.8, which was better than the mean MAS improvement by 24.9±7.1 points observed among ischemic patients. By week 4, hemorrhagic patients had a mean MAS score of 46.2±7.0, while ischemic patients' mean MAS score was 42.3±8.9.

Thus, the findings suggest that Motor Relearning Program is beneficial for patients with both hemorrhagic and ischemic stroke since it helped them improve their motor skills several weeks after stroke. However, hemorrhagic patients appear to benefit more from the Motor Relearning Program in the short term because their mean MAS score was higher at baseline and tended to show greater improvements than those of the ischemic patients. Overall, the sample size was very large for both groups, which ensures reliability and minimizes sampling errors. Moreover, the study revealed week by week motor skill improvements among patients with hemorrhagic and ischemic stroke following the MRP therapy course.

Table 3: Free Functional Scale (FFS) – Total Scores

Group	Baseline (0 wk.)	Week 1	Week 2	Week 3	Week 4	FFS Gain
Ischemic (n=72)	58.1 ± 27.5	74.0 ± 30.1	79.2 ± 29.4	88.5 ± 28.7	99.1 ± 27.9	41.0 ± 24.8
Hemorrhagic (n=72)	43.0 ± 17.1	59.2 ± 22.8	70.5 ± 22.1	89.7 ± 21.9	105.3 ± 21.5	62.3 ± 22.7

Table 3 is an illustration of increased functional independence, which is vital for reintegrating into society. The level of FFS scores at baseline was higher among ischemic patients than hemorrhagic ones: 58.1 versus 43.0, with standard deviations (SD) of 27.5 and 17.1, respectively. By the fourth week, hemorrhagic patients had improved to 105.3 versus 99.1 for ischemic patients, with SDs of 21.5 and 27.9. Thus, the total gains are substantial, ranging from 62.3 for hemorrhagic to 41.0 for ischemic patients, with SDs of 22.7 and 24.8, respectively. In addition to the fact that there were 72 participants in each group, this finding suggests why hemorrhagic strokes are more reversible: they allow patients to perform more activities than those with ischemic ones, given that they have received adequate task oriented rehabilitation.

The week by week assessment confirms that functional independence increases with MRP following the principles of task oriented training. The total number of patients included in the study was sufficient for illustrating the trends that took place during the intervention. Thus, functional independence is gradually gained, which implies the necessity of task oriented rehabilitation in stroke cases.

Table 4: Outcome Measure

Outcome Measure	Ischemic Gain (Mean ± SD)	Hemorrhagic Gain (Mean ± SD)	p-value
MAS	24.9 ± 7.1	31.0 ± 9.8	0.0004
FFS	41.0 ± 24.8	62.3 ± 22.7	0.0002

Together, the data presented in Table 2 and Table 3 can be used to conclude that MRP results in comparable improvements in motor performance and functional independence for the large sample size studied. The difference in gains from the two subtypes of stroke supports the idea that hemorrhagic stroke survivors benefit more from task-oriented rehabilitation than ischaemic ones, especially after the acute period. This is evident from the larger gains reported by the former group in comparison to the latter in both MAS (31.0 ± 9.8 vs. 24.9 ± 7.1; p = 0.0004) and FFS (62.3 ± 22.7 vs. 41.0 ± 24.8; p = 0.0002). Such a difference is possibly explained by the fact that ischaemic stroke survivors have to deal with the consequences of infarction, which is detrimental to motor performance gains.

The results described above support the hypothesis that MRP is beneficial for both subtypes of stroke survivors. The study's sample size is large and sufficient to make reliable conclusions and recommendations for clinical practice. It can be stated that rehabilitation interventions for hemorrhagic stroke survivors may have a more profound impact on motor gains than those for ischaemic stroke survivors. Therefore, rehabilitation interventions for both subtypes should be standardized and task-specific to ensure that patients obtain the maximum therapeutic benefit.

Discussion

The research made to compare how MRP affected the participants who survived an ischemic and hemorrhagic stroke resulted in a positive outcome for both groups of patients. The study included 144 participants (72 in each group). It can be noted that both groups showed improvement in their motor function, which was measured by the Motor Assessment Scale (MAS), as well as an increase in their functional independence, measured by the Free Functional Scale (FFS). Moreover, it was found that the patients who had a hemorrhagic stroke improved more than those who experienced an ischemic stroke from the second week.

The study results are consistent with prior studies, which stress the importance of task-oriented rehabilitation therapy in stroke rehabilitation. Systematic reviews and randomized controlled trials revealed that task-oriented rehabilitation, which incorporates elements of repetitions, practice, and contextual interference, was more effective than traditional approaches. For instance, O'Rourke and Edwards[7] argue that MRP improves upper limb function as compared to conventional therapy. In contrast, Pollock et al.[15] explain that interventions targeting task-specific functional activities lead to better improvements in independence. Higgins et al.[9] report that upper limb function demonstrated statistically significant improvements when a person engages in repeated and targeted practice relative to those who undergo generic therapeutic exercises. Similarly, Singha[10] reveals that MRP is more effective than proprioceptive neuromuscular facilitation in enhancing fundamental motor skills of chronic stroke survivors. In addition, Bian et al. [11] reported that non-immersive virtual reality-based rehabilitation improved lower-extremity motor function and gait in patients with subacute cerebral infarction, although its effectiveness was not significantly different from conventional therapy. Park et al.[12] prove that task-specific training enhances independence in post-stroke individuals as measured by the ability to perform activities of daily living independently. Moreover, Kwakkel et al.[13] demonstrate that robots can be incorporated into task-oriented rehabilitation interventions successfully. Lastly, Langhorne et al.[14] conclude that task-oriented rehabilitation interventions have a positive effect on post-stroke patients. Finally, Pawar et al.[8] confirm that functional electrical stimulation combined with MRP improves the quality of life of ischemic stroke survivors.

The difference in outcome between the two types of patients can be explained by the nature of the disease. Thus, ischemic stroke results in necrosis of brain cells due to the lack of blood supply, which leads to reduced chances of recovery despite the rehabilitation measures used[4,20]. Hemorrhagic stroke can cause substantial primary and secondary neuronal injury, tissue destruction, edema, increased intracranial pressure and permanent neurological deficits.. After the resolution of these complications, the patient can completely recover and is subject to rehabilitation[24]. This explains the results obtained: the initial motor and functional abilities of hemorrhagic patients were lower, but already after four weeks of treatment, they caught up with the ischemic group and showed better results[15, 18]. Billinger et al.[19] concluded that to achieve optimal post-stroke recovery, it is necessary to specifically organize physical activity and exercises for patients. The authors emphasized that motor activity must be integrated into daily life, and physical activity plays a key role in preventing disabilities. Mehrholz et al.[23] proved that post-stroke hemiparetic patients could improve their walking ability through electromechanical-assisted training. These facts highlight the importance of using the MRP for stroke rehabilitation.

Clinically, this research has several implications. First, it highlights the universal benefit of MRP within all stroke types as a rehabilitation tool. Second, it demonstrates the necessity of taking into account the specific characteristics of subtypes when planning the rehabilitation process. Although it appears that both subtypes equally benefit from motor imagery training, the required duration of interventions was shown to differ significantly. Hemorrhagic stroke patients demonstrate a remarkable response to rehabilitation interventions, which appear to have a prolonged effect after the training course. This can be explained by task-oriented motor learning they are able to acquire after the resolution of pathological processes. In addition to the abovementioned factors, the rehabilitation setting also plays an essential role in rehabilitation outcomes after stroke. Caregivers and staff can play an active role in training patients to overcome their functional limitations outside the hospital.

By virtue of a decent sample size selected for this study, researchers could provide the evidence mentioned above with moderate confidence. It was found that stroke subtypes have different recovery patterns following MRP. These facts could be instrumental in determining further areas of research related to the topic. The design of future studies should consider the length of interventions, the possibility of inter-subtype differences, and the importance of applying MRP in combination with robotic devices, VR technology, and FES as advanced practice tools recommended by Moskiewicz et al.[3] and Kwakkel et al.[13]

Future studies should build on these findings by extending follow-up periods to capture long-term outcomes, stratifying ischemic subtypes (e.g., lacunar vs. large vessel strokes), and exploring the integration of MRP with modern technologies such as robotics, virtual reality, and functional electrical stimulation. Such approaches may further enhance recovery and provide personalized rehabilitation strategies tailored to individual patient needs.

Conclusion

Our present study suggests that the Motor Relearning Program is an effective method for the rehabilitation of both ischemic and hemorrhagic stroke patients. This was found from the large sample of 144 participants with a sufficient amount of motor recovery and independence. The hemorrhagic group was also discovered to have had more severe cases and greater recovery than the ischemic group, suggesting that there are differences in the recovery patterns of these stroke types. Also, this study offers valuable insight into the development of successful rehabilitation treatment strategies. For hemorrhagic stroke patients, it can be suggested that they should receive intense treatment as soon as possible after the hemorrhage has stopped. Ischemic stroke patients may benefit from prolonged and varied treatment programs. This study is significant because it provides substantial, generalizable data and promotes the inclusion of such rehabilitation programs in stroke patient care, encouraging more research into the subject and the potential development of even more effective therapies.

Limitations- Sample size and intervention duration were relatively less for more evident result.

Conflict of interest- The authors declare that they have no conflict of interest.

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Authors' Contributions- All authors contributed to the conception and design of the study, data collection, analysis and interpretation of the results, and preparation and revision of the manuscript. All authors approved the final version of the manuscript.

Data Availability- The data may be available from the corresponding author on reasonable request, subject to appropriate ethical and institutional requirements.

Ethical approval- The study was approved by the Institutional Ethics Committee of King George's Medical University (KGMU), Lucknow, Uttar Pradesh, India. Written informed consent was obtained from all participants before enrolment and participation in the study.

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Artificial Intelligence (AI) Use Statement

The authors declare that artificial intelligence (AI) tools were not used to generate, analyze, or interpret the research data or results. AI-assisted tools, if used during manuscript preparation, were limited to language editing and improving readability. The authors take full responsibility for the accuracy, originality, and integrity of the content.

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