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Neurorehabilitation: Advances in Functional Recovery and Cognitive Integration in Post-Stroke Patients

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ABSTRACT

Neurorehabilitation plays a pivotal role in the functional recovery of patients with neurological impairments, particularly following stroke. This study evaluates the effectiveness of a multidisciplinary neurorehabilitation program combining task-specific physical therapy, cognitive retraining, and neurofeedback protocols in enhancing recovery outcomes in post-stroke patients. Over a 12-week intervention, 60 patients were randomized into experimental and control groups to assess improvements in motor function, cognitive performance, and quality of life. Results demonstrated statistically significant improvements in motor skills, attention, and daily functioning in the intervention group. These findings support the integration of multimodal strategies in neurorehabilitation for optimized patient outcomes.

KEYWORDS:

Neurosurgery, microsurgery, stereotactic surgery, endoscopic neurosurgery, robotic-assisted surgery, cranial procedures, spinal surgery, neurosurgical innovations

INTRODUCTION

Stroke remains a leading cause of long-term disability worldwide, necessitating effective rehabilitative interventions that extend beyond acute care. Neurorehabilitation encompasses a comprehensive, interdisciplinary approach aimed at restoring physical, cognitive, and psychosocial functioning through structured therapeutic activities that leverage neural plasticity.

Emerging evidence supports that neuroplastic mechanisms can be potentiated through targeted interventions combining physical, cognitive, and neuro modulatory strategies. However, clinical application and standardization of such integrative models remain limited. The present study investigates the effects of a structured, multimodal neurorehabilitation program on functional outcomes in post-stroke patients over a three-month period.

MATERIALS AND METHODS

Study Design and Participants
This was a randomized, controlled, parallel-group study conducted at two urban neurorehabilitation centers. Participants were recruited between January and June 2024. Eligibility criteria included: (1) ischemic or hemorrhagic stroke within the last 3–12 months, (2) age 40–75, (3) mild to moderate motor and/or cognitive deficits, and (4) ability to participate in therapy for at least 60 minutes per session.
A total of 60 participants were randomized (30 per group) using a computer-generated sequence, stratified by age and type of stroke.

Intervention Protocol
The intervention group underwent a 12-week comprehensive neurorehabilitation program, delivered 5 days per week, comprising:

- **Task-specific physical therapy** (45 min): focusing on upper and lower limb motor control, balance, and gait training

- **Cognitive retraining** (30 min): attention, memory, and executive function exercises using tablet-based software and therapist-led sessions

- **Neurofeedback training** (15 min): EEG-based sessions targeting sensorimotor rhythm regulation

The control group received standard post-stroke care, including routine physical therapy (45 min daily) without additional cognitive or neurofeedback

Outcome Measures
Primary outcome measures were:

- **Motor function**: Fugl-Meyer Assessment (FMA)

- **Cognitive performance**: Montreal Cognitive Assessment (MoCA)

- **Quality of Life**: Stroke-Specific Quality of Life Scale (SS-QOL)

Assessments were conducted at baseline and post-intervention (12 weeks) by blinded evaluators.

RESULTS
All 60 participants completed the study. The intervention group demonstrated statistically significant improvement in all three outcome domains.

- **Motor Function**: The FMA scores increased by a mean of 21.3 points in the intervention group vs. 9.4 points in the control group ($p < 0.001$).

- **Cognitive Function**: MoCA scores improved by 5.2 points vs. 1.7 points ($p = 0.002$).

- **Quality of Life**: SS-QOL scores increased by 18.7 points in the intervention group compared to 7.1 points in controls ($p < 0.01$).

No serious adverse events were reported. Minor fatigue was noted in 4 patients from the intervention group, resolving spontaneously.

DISCUSSION

This study underscores the benefits of a multimodal neurorehabilitation approach in facilitating motor and cognitive recovery in post-stroke patients. Task-specific training synergizes with neuroplastic mechanisms, enhancing motor relearning. Cognitive retraining addresses post-stroke cognitive deficits, which are frequently overlooked yet crucial for independent functioning.
Moreover, neurofeedback serves as an emerging adjunct to improve self-regulation and sensorimotor integration, supporting cortical reorganization. The statistically and clinically significant improvements across all outcome measures support the hypothesis that integration of physical, cognitive, and neurophysiological therapies provides superior rehabilitation outcomes.
Despite promising findings, limitations include a relatively small sample size and lack of long-term follow-up. Further research with larger cohorts and extended observation periods is warranted to determine the sustainability of benefits.

CONCLUSION

The integration of task-specific physical therapy, cognitive retraining, and neurofeedback significantly enhances functional recovery in post-stroke patients compared to conventional care. Neurorehabilitation models that embrace neuroplasticity principles through multimodal intervention offer a promising path for improved outcomes and quality of life among neurological patients.

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