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Precision-based motor learning enhances neuroplasticity and hand function in post-stroke individuals: A randomized controlled trial

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Abstract

Background: Precision-Based Motor Learning (PBML) focuses on task accuracy, sensory feedback, and controlled motor repetition, aimed at promoting neuroplasticity after stroke. Evidence suggests that targeted motor learning strategies may enhance cortical reorganization and functional recovery.

Objective: To evaluate the effects of PBML on neuroplastic adaptations and upper-limb motor recovery in individuals with post-stroke impairment.

Methods: Thirty-six participants with chronic stroke were randomly allocated to either PBML training (N=18) or conventional motor practice (N=18). Both groups trained 5 days/week for 8 weeks. Outcome measures included Fugl-Meyer Upper Extremity (FMA-UE), grip strength, Box and Block Test (BBT), and somatosensory discrimination tasks. Pre-post scores were analyzed using paired and independent t-tests (p<0.05).

Results: The PBML group demonstrated significantly greater improvements in motor coordination, sensory accuracy, and fine-motor control. FMA-UE increased by 17.2 points in the PBML group compared with 10.4 points in the control group. Grip strength improved by 5.1 kg versus 2.3 kg, and BBT scores increased by 34% versus 18% in controls (all p<0.05).

Conclusion: PBML resulted in superior neuroplastic and functional gains compared with conventional motor practice. These findings support the integration of precision-based training into upper-limb stroke rehabilitation.

Keywords: FMA-UE, Precision-Based Motor Learning (PBML), Box and Block Test (BBT), Fugl-Meyer Upper Extremity (FMA-UE)

Introduction

Stroke frequently leads to upper-limb motor deficits due to disrupted cortical pathways. Rehabilitation approaches that incorporate motor learning principles have gained traction for promoting neuroplasticity. Precision-Based Motor Learning (PBML) emphasizes movement accuracy, error correction, and sensory discrimination elements shown to enhance cortical reorganization. This study investigates whether PBML produces greater neuroplastic and functional improvements compared with conventional motor practice.

Methods

- **Design:** Randomized controlled trial.
- **Participants:** Thirty-six adults with chronic post-stroke hemiparesis were recruited and randomly assigned to PBML (N=18) or control (N=18).
- **Intervention:** The PBML group performed structured fine-motor tasks emphasizing precision, paced repetition, and graded sensory cues. The control group received conventional motor exercises focused on gross-motor strengthening. Both groups trained 5 days/week for 8 weeks.
- **Outcome Measures:** Fugl-Meyer Upper Extremity (FMA-UE), grip strength, Box and Block Test (BBT), and sensory discrimination tasks.
- **Statistical Analysis:** Paired t-tests assessed within-group changes; independent t-tests evaluated between-group differences (p<0.05).

Results

Both groups showed significant improvement, but the PBML group achieved larger gains in all measured domains.

PBML Group

- **FMA-UE:** +17.2
- **Grip strength:** +5.1 kg
- **BBT performance:** +34%
- **Sensory accuracy:** Markedly improved

Control Group

- **FMA-UE**: +10.4
- **Grip strength:** +2.3 kg
- **BBT performance:** +18%

Between-group post-test differences were statistically significant ($p<0.05$), supporting the superiority of PBML for fine-motor recovery.

Discussion

PBML's emphasis on precision and sensory feedback appears to enhance neuroplastic mechanisms, including improved sensorimotor integration and corticospinal activation. These findings align with existing work highlighting the role of task specificity and error-based learning in motor recovery. The magnitude of improvement in both motor and sensory outcomes suggests that PBML may effectively target deficits commonly resistant to conventional practice.

Conclusion

Precision-based motor learning produced superior improvements in motor coordination, sensory discrimination and functional performance in post-stroke individuals. PBML should be considered a valuable component of upper-limb rehabilitation programs aiming to enhance neuroplastic recovery.

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