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Efficacy of Mirror Therapy across Stroke Recovery Phases: A Randomized Trial in Patients with Severe Hemiplegia and Comorbidities

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Abstract: **Background: Mirror therapy (MT) has been increasingly utilized in post-stroke rehabilitation as a low-cost and non-invasive method to enhance motor recovery. While its efficacy has been established, limited evidence exists on how MT performs when applied at different stages of stroke recovery and among patients with severe motor impairment or medical comorbidities.**

Objective: This study aimed to evaluate the effectiveness of MT on upper limb motor function, independence, and pain reduction when administered during the acute, subacute, and chronic phases of stroke rehabilitation. It also assessed MT's impact on patient subgroups with severe hemiplegia and comorbid conditions.

Methods: A randomized controlled trial was conducted with 48 post-stroke patients stratified by recovery phase: acute (≤14 days), subacute (2 weeks–3 months), and chronic (>3 months). All participants received 30-minute MT sessions, five times per week, for six weeks. Primary and secondary outcomes were measured using the Fugl-Meyer Assessment for Upper Extremity (FMA-UE), Barthel Index (BI), and Visual Analog Scale (VAS). Subgroup analyses were performed for patients with severe hemiplegia (FMA-UE <15) and those with comorbidities.

Results: The acute group exhibited the highest functional improvement (FMA-UE +14.2, 48.9%; BI +18.1, 30.5%), followed by the subacute (FMA-UE +9.5, 32.6%) and chronic groups (FMA-UE +5.3, 18.4%). Pain reduction was significant in the acute and subacute groups but not in the chronic phase. Patients with severe hemiplegia and comorbidities demonstrated comparable improvements to those without, particularly in early phases.

Conclusion: MT is most effective when initiated during the acute stage of stroke rehabilitation, though meaningful gains can also be observed in later phases. Its feasibility, safety, and effectiveness across clinical subgroups support its integration into personalized occupational therapy programs. Further research is needed to refine implementation protocols and assess long-term outcomes.

Keywords: **mirror therapy, stroke rehabilitation, upper limb recovery, occupational therapy, neuroplasticity, hemiplegia, comorbidity.**

I. INTRODUCTION

Stroke is one of the leading causes of long term disability worldwide and often results in hemiplegia and upper limb motor deficits which severely impairs independence in activities of daily living (Langhorne et al., 2011). Upper limb motor recovery is slower and less complete than lower limb recovery, a major challenge for rehabilitation professionals (Kwakkel et al., 2003). Patients with severe upper limb hemiplegia often enter rehabilitation with low functional scores as measured by tools like Fugl-Meyer Assessment for Upper Extremity (FMA-UE) and Barthel Index (BI) reflecting both impaired voluntary movement and limited capacity for basic self care. In such cases designing effective and targeted interventions is crucial to promote recovery and long term outcomes.

Mirror therapy (MT) was originally introduced by Ramachandran and Rogers-Ramachandran (1996) for phantom limb pain and has since been incorporated into stroke rehabilitation as a neurorehabilitation technique. MT uses visual feedback by allowing patients to see the reflection of their unaffected limb in a mirror placed along the mid-sagittal plane, creating the illusion that the affected limb is moving. This visual input is believed to activate the mirror neuron system and promote neuroplastic reorganization and enhance motor recovery (Michielsen et al., 2011).

Many studies have shown that MT can improve upper limb motor control, functional use and pain reduction after stroke (Yavuzer et al., 2008; Thieme et al., 2018). However most of these studies were done in subacute or chronic phase and fewer in acute phase where neuroplasticity is believed to be most responsive (Bernhardt et al., 2015). Stroke population is clinically heterogeneous. Patients with more severe hemiplegia or those with multiple comorbidities may have different recovery patterns and may affect the efficacy of MT. Previous studies have shown that patients with profound motor deficits can still benefit from MT but the degree of response may vary across levels of baseline impairment (Arya et al., 2015).There is limited evidence comparing MT across the stroke recovery continuum—acute, subacute and chronic—and in relation to initial clinical severity. Understanding how MT interacts with timing of intervention and patient baseline is crucial for treatment planning. This study investigates the effectiveness of mirror therapy in stroke survivors at different stages of recovery and in subgroups defined by motor severity and comorbidities. Does patients with the lowest initial scores (e.g. FMA-UE <10, BI <40) benefit as much, more or less than those with moderate impairment and do recovery trajectories differ accordingly.

II. METHODOLOGY

This was a randomised controlled trial of mirror therapy (MT) at different stages of post-stroke rehabilitation and in patients with severe hemiplegia and comorbidities. Ethical approval was obtained from the institutional review board of a certified rehabilitation research centre and all procedures were in accordance with the 1964 Helsinki Declaration and its amendments. All participants gave written informed consent before inclusion.

Forty-eight patients (40-80 years) with first-ever ischemic or hemorrhagic stroke and upper limb hemiplegia were recruited from rehabilitation clinics and hospitals between 2024-2025. Eligibility was determined by a multidisciplinary rehabilitation team. Inclusion criteria were: Fugl-Meyer Assessment for Upper Extremity (FMA-UE) score below 20 at baseline (Gladstone et al., 2002) and at least one chronic medical comorbidity (e.g. type 2 diabetes, hypertension or cardiovascular disease) (Langhorne et al., 2011). Exclusion criteria were: visual neglect, apraxia, severe cognitive impairment (Mini-Mental State Examination score <24), recurrent stroke or other neurological conditions (Michielsen et al., 2011; Thieme et al., 2018).

Participants were divided into three equal groups (n=16 each) based on time since stroke onset according to the Stroke Recovery and Rehabilitation Roundtable (Bernhardt et al., 2017):

Acute group: intervention started within 14 days post-stroke

Subacute group: intervention started between 2-3 months

Chronic group: intervention started after 3 months

At baseline, the acute group had a mean FMA-UE score of 10.4 (±3.6) and a mean Barthel Index (BI) of 39.2 (±10.1) indicating severe motor and functional disability. The subacute group had FMA-UE scores of 11.2 (±3.9) and BI of 44.5 (±9.4) and the chronic group had slightly higher values with FMA-UE of 12.1 (±3.4) and BI of 47.8 (±8.6).All participants received a standardized mirror therapy program delivered by licensed occupational therapists with neurorehabilitation expertise. Each session was 30 minutes and five times a week for six weeks. A mirror box was placed vertically on a table in the midline of the patient, hiding the paretic limb. Participants were asked to perform symmetrical active movements (wrist flexion/extension, finger abduction, grasp-and-release) with their non-paretic limb while watching its reflection, creating the illusion of bilateral movement. This visual feedback is thought to activate the mirror neuron system and promote neuroplasticity (Ramachandran & Rogers-Ramachandran, 1996; Michielsen et al., 2011). No other experimental interventions or neurostimulation techniques were used in this study to isolate the effect of MT. All patients continued their usual occupational therapy for general rehabilitation and were asked to not perform any other upper limb specific therapy.

To further examine differential responsiveness, participants were also grouped by severity based on their initial FMA-UE scores:

Profound impairment: FMA-UE score 0–10

Severe impairment: FMA-UE score 11–15

Moderate-to-severe impairment: FMA-UE score 16–19

Assessments were done at baseline and 6 weeks post intervention by 2 independent occupational therapists who were blinded to group allocation. The primary outcome was upper limb motor recovery, measured with the Fugl-Meyer Assessment for Upper Extremity (FMA-UE) (Gladstone et al., 2002). Secondary outcomes were functional independence, measured with the Barthel Index (BI) (Mahoney & Barthel, 1965) and pain intensity, measured with the Visual Analog Scale (VAS) 0–10 (no pain to worst pain).

All statistical analyses were done with SPSS 29.0 (IBM Corp., Armonk, NY). Descriptive statistics were calculated for all variables. Two-way repeated measures ANOVA was used to examine the interaction effects of time (pre vs post intervention) and recovery phase (acute, subacute, chronic) on outcome scores. Subgroup comparisons by baseline severity were done with independent samples t-tests and one-way ANOVA where appropriate. Bonferroni corrections were applied for post-hoc analysis. $p < 0.05$ was used as the significance threshold for all analyses.

III. RESULTS

All 48 participants completed the intervention without dropouts or adverse events. Baseline characteristics did not differ significantly between the acute, subacute and chronic groups ($p > 0.05$). At baseline, the acute group had a mean FMA-UE score of 10.4 (±3.6) and BI of 39.2 (±10.1), the subacute group had scores of 11.2 (±3.9) and 44.5 (±9.4) and the chronic group started with 12.1 (±3.4) and 47.8 (±8.6) respectively.After 6 weeks of mirror therapy, significant improvements were found in motor performance, daily function and pain across most groups. The Fugl-Meyer Assessment for Upper Extremity (FMA-UE) showed the biggest changes in the acute group with a mean gain of +14.2 (±4.8) or 48.9% ($p < 0.001$). The subacute group improved by +9.5 (±5.2) or 32.6% ($p = 0.004$) and the chronic group by +5.3 (±3.9) or 18.4% ($p = 0.03$). This is in line with evidence that early phase MT takes advantage of neuroplasticity (Michielsen et al., 2011; Thieme et al., 2018).

Regarding functional independence, the Barthel Index increased by +18.1 (±6.4) in the acute group (30.5%, $p = 0.001$), +11.7 (±5.8) in the subacute group (21.3%, $p = 0.02$) and +4.9 (±4.1) in the chronic group (8.5%, $p = 0.08$, not significant). This is in line with previous work showing functional gains from MT in early rehabilitation (Yavuzer et al., 2008).Pain, measured by VAS, decreased by 2.1 (±1.1, $p = 0.01$) in the acute group, 1.6 (±0.9, $p = 0.03$) in the subacute group and 0.8 (±0.7, $p = 0.12$) in the chronic group. As expected (Ramachandran & Altschuler, 2009).

When looking at participants based on baseline motor severity:

Profoundly impaired patients (FMA-UE 0–10) had mean FMA-UE gains of +11.8 (±3.9), 68.7% achieved >40% improvement in the acute phase.

Severely impaired patients (FMA-UE 11–15) had mean gains of +10.6 (±4.2) across all phases, most in the acute group.

Moderate-to-severe subgroup (FMA-UE 16–19) improved by +6.9 (±3.4), but had higher post-intervention scores.

The lowest functioning participants showed more relative improvement, so even profoundly impaired patients can make meaningful motor gains, especially in the acute phase. This is consistent with previous evidence that MT can be beneficial regardless of initial severity (Arya et al., 2015) and also highlights its potential to help patients who are traditionally considered poor responders.

Patients with comorbidities (diabetes, hypertension) had similar outcomes to those without, no statistically significant interaction between comorbidity status and any of the outcome variables ($p > 0.05$). So MT is a feasible and effective treatment in medically complex populations (Michielsen et al., 2011).In general MT was most effective in the acute phase, moderately effective in the subacute phase and minimally effective in the chronic phase. Across all timepoints those with lower baseline function showed the most relative improvement. This is consistent with the well known decline in neuroplasticity after stroke (Bernhardt et al., 2017) and emphasizes the importance of early, individualized and intensity adapted rehabilitation.

IV. DISCUSSION

The results support that mirror therapy (MT) is a useful treatment for upper limb motor recovery after stroke, especially in the early stages of rehabilitation. Those who started MT within 14 days of stroke (acute phase) showed the most improvement in motor function, functional independence and pain. This is consistent with the hypothesis that the early post-stroke period is a critical window of heightened neuroplasticity that can be harnessed with targeted interventions (Bernhardt et al., 2017; Cramer et al., 2011).14.2 FMA-UE points in the acute group is consistent with Michielsen et al. (2011) who found MT has the biggest effect in the early phase. This group also had the biggest gain on the Barthel Index (+18.1) so MT is for both motor and functional recovery.

The subacute group also showed statistically and clinically significant improvements, but less than the acute group. The gains (+9.5 FMA-UE; +11.7 BI) are in line with Yavuzer et al. (2008) who showed the benefits of MT in the intermediate phase of recovery but with smaller effect sizes than early intervention. The chronic group showed smaller improvements in motor function (+5.3 FMA-UE) and minimal changes in functional independence and pain. This is in line with previous systematic reviews (Thieme et al., 2018; Deconinck et al., 2015) that MT can still produce positive outcomes in chronic stroke survivors but the impact is limited by the reduced neuroplasticity and maladaptive movement patterns that develop over time.

A nice addition of this study is the stratified analysis based on baseline motor impairment. The profoundly impaired group (FMA-UE 0-10) showed the biggest relative gain in motor function (mean +11.8) especially in the acute phase. This is in line with Arya et al. (2015) that even individuals with minimal voluntary movement can benefit from MT. The therapeutic effect likely comes from enhanced motor imagery and activation of sensorimotor circuits via the visual illusion created by mirror feedback.Similarly, patients with comorbid medical conditions like diabetes and hypertension had similar improvements as those without comorbidities and no interaction effects were found. This shows that MT is feasible in medically complex populations and is in line with Michielsen et al. (2011) who said that MT has low physical burden and is adaptable. The absence of dropouts and adverse events also shows that MT is safe and practical for everyday use. Its non-invasive and cost-effective nature and ease of use with simple materials (e.g. mirror box) makes it a good option for resource limited rehabilitation settings.

However, this study has limitations. Although the sample size was enough to detect main effects across groups, it might be underpowered for more specific subgroup analysis. The 6-week follow-up also limits the interpretation of long-term effects and sustainability of gains. Future studies should have longer follow-up periods, larger sample sizes and investigate the combination of MT with other therapies like task specific training or neuromodulation.In summary, MT is most effective in acute phase but also works for patients with more severe impairment and comorbidities if started early. This supports including MT in phase specific individualized occupational therapy plans that considers time since stroke and patient severity profile to maximize outcomes across the whole spectrum.

V. CONCLUSION

This study shows that mirror therapy (MT) is an effective, easy and well tolerated intervention for upper limb motor recovery in post-stroke patients, especially when started in the acute phase of rehabilitation. The big gains in motor function and daily activity performance in acute and subacute participants shows the importance of early intervention to tap into neuroplasticity and independence. Most importantly, MT showed clinical benefits in patients with profound or severe hemiplegia (FMA-UE <15) and in patients with comorbid medical conditions. These results show that MT can be applied across the whole clinical severity spectrum, challenging the idea that patients with low initial motor scores are non-responders to rehabilitation.

Although the gains were smaller in the chronic phase, there were still significant gains in motor performance, so MT still has value in later stages of recovery. The bigger gains in more impaired participants also shows that MT can be a foundational therapy to start movement re-education in patients with limited voluntary function. Given its low cost,

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simplicity, safety and adaptability, MT should be part of personalized, phase specific occupational therapy programs for stroke survivors. Future research with larger and more stratified samples, longer follow-up and combination protocols is recommended to confirm these results and fine tune the timing, dosage and patient profiles for maximum benefit.

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