

The Use of Mirror Therapy for Phantom Limb Pain and Function in Amputees: Evaluating Efficacy and Clinical Outcomes

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Abstract

Objective: This study investigates the effectiveness of mirror therapy in managing phantom limb pain (PLP) and enhancing function in amputees.

Methods: A randomized controlled trial was conducted with 30 amputees (15 in the mirror therapy group and 15 in the control group). The mirror therapy group received 30-minute sessions of mirror therapy three times per week for 12 weeks, while the control group continued with standard care. Outcomes were measured using the Visual Analogue Scale (VAS) for pain, the McGill Pain Questionnaire (MPQ) for pain quality, and the Jebsen-Taylor Hand Function Test (JTHFT) and Timed Up and Go Test (TUG) for motor function.

Results: The mirror therapy group demonstrated significant reductions in PLP, with VAS scores decreasing from 7.6 ± 1.2 to 4.0 ± 1.1 and MPQ total scores improving from 35.4 ± 8.7 to 18.2 ± 6.5 . Motor function also improved, with JTHFT scores for upper limb amputees improving from 45.2 ± 12.3 to 30.5 ± 10.2 and TUG scores for lower limb amputees improving from 15.6 ± 3.2 to 12.4 ± 2.9 . The control group showed less improvement in these measures.

Conclusion: Mirror therapy is effective in reducing phantom limb pain and improving motor function in amputees. These findings support the integration of mirror therapy into rehabilitation programs for enhanced patient outcomes.

Keywords: Phantom Limb Pain, Mirror Therapy, Amputees, Motor Function, Rehabilitation, Randomized Controlled Trial

Introduction

Phantom limb pain (PLP) is a prevalent and distressing condition experienced by many amputees, characterized by the sensation of pain in a limb that is no longer present. Studies estimate that between 60% and 80% of amputees experience PLP, which can significantly impact their quality of life and functional outcomes (Chan et al., 2007; Moseley and Flor, 2012). Despite the high incidence of PLP, effective treatments remain limited, and management strategies often focus on pain relief and improving functional outcomes.

Mirror therapy has emerged as a novel approach for addressing PLP. This therapeutic technique involves the use of a mirror placed in such a way that the reflection of the intact limb appears as the missing limb, creating the illusion of a complete body. The rationale behind mirror therapy is based on the concept of neuroplasticity and the idea that visual feedback can modify sensory and motor pathways in the brain (Hagenberg and Carpenter, 2014). Initial studies have shown that mirror therapy can reduce PLP and improve motor function by providing visual feedback that can alter the brain's representation of the body (Yildirim and Sen, 2020; Barbin et al., 2016).

Despite promising results, there is still a need for more rigorous research to confirm the efficacy of mirror therapy for PLP and to understand its impact on functional recovery. Previous studies have demonstrated variable results, and the optimal parameters for therapy remain unclear (Seidel et al., 2009; Herrador Colmenero et al., 2018). Therefore, this study aims to evaluate the effectiveness of mirror therapy in managing PLP and enhancing functional outcomes in amputees. By addressing this gap in the literature, the study seeks

to provide clearer insights into the potential benefits of mirror therapy and its practical applications in clinical settings.

Literature Review

Phantom Limb Pain (PLP): Phantom limb pain (PLP) is a common phenomenon among amputees, characterized by the sensation of pain in an absent limb. It is estimated that between 60% and 80% of individuals with limb amputations experience PLP, which can vary in intensity and quality, affecting their overall quality of life and functional abilities (Chan et al., 2007; Moseley and Flor, 2012). The mechanisms underlying PLP are not entirely understood but are believed to involve maladaptive cortical reorganization and the persistence of neural representations of the missing limb in the brain (Seidel et al., 2009).

Current Treatments for PLP: Traditional treatments for PLP include pharmacological approaches, such as analgesics, opioids, and anticonvulsants, as well as non-pharmacological methods like nerve blocks, acupuncture, and cognitive-behavioral therapy (Barbin et al., 2016). However, these treatments often provide only partial relief and can be associated with side effects or limited efficacy. There is a growing need for alternative or complementary therapies that address the underlying neural mechanisms of PLP more directly.

Mirror Therapy: Mirror therapy is a promising intervention for PLP that utilizes visual feedback to address the sensory-motor conflict associated with phantom limbs. The technique involves placing a mirror in a position where the reflection of the intact limb creates the illusion of a complete body, allowing the patient to perform movements that simulate the missing limb (Hagenberg and Carpenter, 2014). This visual feedback can help to reorganize the cortical representation of the limb and reduce the experience of pain (Yildirim and Sen, 2020).

Mechanisms and Efficacy: The theoretical basis of mirror therapy lies in its ability to induce neuroplastic changes in the brain. By providing a visual representation of the missing limb, mirror therapy may help to recalibrate the brain's body schema and alleviate the sensory-motor mismatch that contributes to PLP (Hagenberg and Carpenter, 2014). Studies have shown that mirror therapy can lead to significant reductions in PLP and improvements in motor function. For example, a randomized controlled trial by Herrador Colmenero et al. (2018) found that mirror therapy significantly reduced PLP intensity and improved motor function compared to a control group.

Yildirim and Sen (2020), conducted a study that demonstrated the effectiveness of mirror therapy in reducing PLP and improving motor function in individuals with upper-limb amputations. Their results indicated that patients who received mirror therapy reported a significant reduction in pain and an improvement in phantom limb sensations. Similarly, a meta-analysis by Seidel et al. (2009) confirmed that mirror therapy is effective in reducing PLP, though the variability in response suggests the need for standardized protocols and further research.

Gaps in Research: Despite the promising findings, there are several gaps in the current research on mirror therapy for PLP. The effectiveness of mirror therapy may vary based on factors such as the duration of treatment, frequency of sessions, and the specific techniques used (Herrador Colmenero et al., 2018). Additionally, while many studies report positive outcomes, there is a lack of consensus on the optimal treatment parameters and long-term benefits. Further research is needed to determine the most effective protocols and to explore how mirror therapy can be integrated into comprehensive pain management strategies for amputees.

Methodology

Study Design: This research was conducted as a quantitative, randomized controlled trial (RCT) to evaluate the effectiveness of mirror therapy in managing phantom limb pain (PLP) and enhancing function in amputees. The study was designed to compare the outcomes of mirror therapy with a control intervention over a 12-week period.

Participants: A total of 30 amputees with phantom limb pain were recruited from a tertiary hospital. Participants were randomly assigned to either the mirror therapy group (n=15) or the control group (n=15).

Inclusion criteria included:

1. unilateral upper or lower limb amputation
2. presence of phantom limb pain for at least 6 months

- age between 18 and 75 years.

Exclusion criteria included:

- significant cognitive impairment
- active skin infections or wounds in the residual limb
- recent or ongoing participation in other experimental pain treatments.

Intervention

- Mirror Therapy Group:** Participants in the mirror therapy group underwent a structured mirror therapy program, consisting of 30-minute sessions, three times per week for 12 weeks. During each session, participants performed guided exercises involving both the intact and phantom limbs, using a mirror to create a visual illusion of the missing limb. The therapy protocol followed a standardized procedure, including movements designed to address both pain and motor function.
- Control Group:** Participants in the control group received standard care, which included routine pain management and physical therapy. This group did not receive mirror therapy but continued with their usual treatment regimen, which was monitored to ensure consistency.

Outcome Measures

Primary Outcome - Phantom Limb Pain:

- Visual Analogue Scale (VAS):** PLP intensity was assessed using a 10-point Visual Analogue Scale, where 0 indicated no pain and 10 indicated the worst possible pain. Assessments were conducted at baseline, 6 weeks, and 12 weeks.

Secondary Outcomes - Functional Improvement:

- McGill Pain Questionnaire (MPQ):** To evaluate the quality and intensity of phantom limb pain, the McGill Pain Questionnaire was used at the same intervals as the VAS.
- Motor Function:** Motor function was assessed using the Jebsen-Taylor Hand Function Test (JTHFT) for upper limb amputees and the Timed Up and Go Test (TUG) for lower limb amputees, with measurements taken at baseline and 12 weeks.

Data Collection: Data were collected at three time points: baseline, 6 weeks, and 12 weeks. Pain assessments and functional tests were administered by trained researchers who were blinded to group allocation to minimize bias. All participants were instructed to maintain their usual activities and report any changes in their condition.

Statistical Analysis: Data were analyzed using SPSS software (version 27.0). Descriptive statistics, including means and standard deviations, were calculated for all variables. Between-group differences in pain scores and functional outcomes were assessed using independent t-tests for continuous variables and chi-square tests for categorical variables. Within-group changes over time were analyzed using repeated measures ANOVA. A p-value of <0.05 was considered statistically significant.

Ethical Considerations: The study was approved by the ethics committee, and all participants provided written informed consent before enrollment. Confidentiality and data protection measures were strictly adhered to throughout the study.

Findings

Participant Characteristics: A total of 30 participants (15 in the mirror therapy group and 15 in the control group) completed the study. The demographics and baseline characteristics of the participants are summarized in Table 1.

Table 1: Baseline Characteristics of Participants

Characteristic	Mirror Therapy Group (n=15)	Control Group (n=15)	p-value
Age (mean ±SD)	55.2 ±8.3	54.7 ±7.9	0.78
Gender (M/F)	10/5	11/4	0.72

Amputation Level:			
Upper Limb	6	7	0.69
Lower Limb	9	8	0.69
Duration of PLP (months, mean \pm SD)	18.4 \pm 5.1	17.9 \pm 4.8	0.82

Phantom Limb Pain: Table 2 presents the results of phantom limb pain assessments using the Visual Analogue Scale (VAS) and the McGill Pain Questionnaire (MPQ) at baseline, 6 weeks, and 12 weeks.

Table 2: Phantom Limb Pain Assessments

Measure	Mirror Therapy Group (mean \pm SD)	Control Group (mean \pm SD)	p-value
VAS Score			
Baseline	7.6 \pm 1.2	7.5 \pm 1.1	0.83
6 Weeks	5.2 \pm 1.3	6.8 \pm 1.4	0.02
12 Weeks	4.0 \pm 1.1	6.9 \pm 1.5	0.01
MPQ Total Score			
Baseline	35.4 \pm 8.7	34.8 \pm 9.1	0.79
6 Weeks	23.6 \pm 7.9	30.5 \pm 8.4	0.03
12 Weeks	18.2 \pm 6.5	31.2 \pm 8.9	0.01

Functional Improvement: Table 3 shows the results for motor function assessments using the Jebsen-Taylor Hand Function Test (JTHFT) and the Timed Up and Go Test (TUG) at baseline and 12 weeks.

Table 3: Functional Improvement

Measure	Mirror Therapy Group (mean \pm SD)	Control Group (mean \pm SD)	p-value
JTHFT (Upper Limb)			
Baseline	45.2 \pm 12.3	46.1 \pm 11.8	0.75
12 Weeks	30.5 \pm 10.2	43.0 \pm 12.5	0.01
TUG Test (Lower Limb)			
Baseline	15.6 \pm 3.2	16.1 \pm 3.4	0.67
12 Weeks	12.4 \pm 2.9	15.8 \pm 3.5	0.02

Discussion

This study aimed to evaluate the effectiveness of mirror therapy in managing phantom limb pain (PLP) and enhancing functional outcomes in amputees. The results demonstrated that mirror therapy significantly reduced PLP and improved motor function compared to a control group receiving standard care.

Reduction in Phantom Limb Pain: The findings indicate that mirror therapy led to substantial reductions in PLP, as evidenced by significant improvements in both Visual Analogue Scale (VAS) and McGill Pain Questionnaire (MPQ) scores. The VAS scores in the mirror therapy group decreased from 7.6 \pm 1.2 at baseline to 4.0 \pm 1.1 at 12 weeks, while the control group only showed a minor reduction from 7.5 \pm 1.1 to 6.9 \pm 1.5. Similarly, MPQ total scores improved from 35.4 \pm 8.7 to 18.2 \pm 6.5 in the mirror therapy group, whereas the control group experienced less change. These results are consistent with previous research suggesting that mirror therapy can effectively alleviate PLP by addressing the sensory-motor mismatch and promoting neural recalibration (Hagenberg and Carpenter, 2014; Yildirim and Sen, 2020).

Improvement in Motor Function: The study also found significant improvements in motor function among participants receiving mirror therapy. For upper limb amputees, Jebsen-Taylor Hand Function Test (JTHFT) scores improved from 45.2 ± 12.3 to 30.5 ± 10.2 , indicating enhanced hand function. For lower limb amputees, Timed Up and Go (TUG) Test scores improved from 15.6 ± 3.2 to 12.4 ± 2.9 , demonstrating better mobility. These improvements are aligned with previous studies that have reported enhanced motor function as a result of mirror therapy (Herrador Colmenero et al., 2018; Seidel et al., 2009). The ability of mirror therapy to facilitate motor function may be attributed to its impact on neuroplasticity, allowing for better integration and utilization of the residual limb and intact limb.

Comparison with Control Group: The control group, which continued with standard care, did not show significant improvements in PLP or motor function over the study period. This underscores the potential advantages of integrating mirror therapy into routine management for amputees with PLP. While standard care typically includes pharmacological and physical therapy interventions, these may not address the neurophysiological aspects of PLP as effectively as mirror therapy (Barbin et al., 2016).

Clinical Implications: The results suggest that mirror therapy can be a valuable addition to the treatment regimen for amputees experiencing PLP. By providing visual feedback and promoting neural adaptation, mirror therapy addresses both the pain and functional deficits associated with PLP. Clinicians should consider incorporating mirror therapy into multidisciplinary pain management and rehabilitation programs to enhance patient outcomes.

Limitations and Future Research: This study has several limitations. The sample size was relatively small, which may limit the generalizability of the findings. Additionally, the study's duration was 12 weeks, and longer follow-up periods are needed to assess the long-term benefits and sustainability of mirror therapy. Future research should include larger sample sizes, diverse populations, and longer follow-up to validate these findings and optimize treatment protocols.

Furthermore, exploring the mechanisms underlying the effectiveness of mirror therapy could provide deeper insights into its benefits. Research on the optimal frequency, duration, and specific techniques of mirror therapy would help refine its application and enhance its efficacy.

In conclusion, this study supports the use of mirror therapy as an effective intervention for reducing phantom limb pain and improving functional outcomes in amputees. By addressing both pain and motor function, mirror therapy offers a promising approach for enhancing the quality of life for individuals with limb loss.

References

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