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LINK MEDICAL INTERFACE

Comparison of Efficacy of Mirror Therapy vs. Mental Imagery in Reduction of Phantom Limb Pain in Above-Knee Amputee Patients: A Comparative Study

Komal Iftikhar[1], Arif Ali Rana[1], Wajiha Nazeer[1], Samara Shaukat[2], Momina Arshad[3], Hanan Azfar[4], Sumbal Jehan[5], Muhammad Arslan[6], Intsam Aslam[7]

Correspondence
Intsam Aslam
intsamaslam6@gmail.com
Affiliations
1 Superior University, Lahore, Pakistan
2 Afro Asian Institute, Pakistan
3 Riphah International University, Pakistan
4 Bhatti Hospital, Gujranwala, Pakistan
5 Khyber Medical University (KMU), Pakistan
6 Government College University Faisalabad, Pakistan
7 Department of Rehabilitation Sciences, PSRD College of Rehabilitation Sciences, Lahore, Pakistan

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ABSTRACT

Background: Phantom limb pain (PLP) is a common and debilitating condition affecting amputees, characterized by pain in the absent limb. Despite available pharmacological treatments, non-pharmacological interventions like mirror therapy (MT) and mental imagery (MI) have shown promise in managing PLP.
Objective: To compare the efficacy of mirror therapy versus mental imagery in reducing PLP among above-knee amputee patients.
Methods: A randomized clinical trial was conducted at Hamid Latif Hospital and Ghurki Hospital, Lahore, involving 24 above-knee amputees aged 12-75 years with PLP for at least three months. Participants were randomly assigned to Group A (MT) or Group B (MI). MT sessions involved 30 minutes of mirror reflection exercises, while MI sessions included 30 minutes of guided mental visualization of limb movements. Pain was assessed using the Numeric Pain Rating Scale (NPRS) before and after the intervention. Data were analyzed using SPSS 25 with Mann-Whitney U and Wilcoxon signed-rank tests.
Results: Group A showed a significant reduction in NPRS scores with a mean rank of 9.79 (p=0.052), while Group B had a mean rank of 15.21 (p=0.052), indicating a trend towards greater efficacy in the MT group.
Conclusion: Both mirror therapy and mental imagery effectively reduced PLP, with mirror therapy showing a slightly superior effect.

INTRODUCTION

Phantom limb pain (PLP) is a debilitating condition often experienced by individuals who have undergone limb amputation. This neuropathic pain typically manifests in the amputated limb and can also arise following the removal of other body parts. Historical accounts of PLP date back to the 16th century when Ambrose Paré first documented the phenomenon, and later in the 19th century, neurologist Silas Weir Mitchell coined the term "phantom limb pain" (1). PLP encompasses a spectrum of sensations, including phantom limb pain, phantom sensations, and stump pain, which often co-occur and can be challenging to distinguish. These sensations range from benign feelings, such as warmth, to more distressing ones described as burning, cramping, or crushing, occurring sporadically or persistently (2). The etiology of PLP remains incompletely understood; however, it is hypothesized to result from multiple factors, including nerve irritation, central nervous system changes, and a mismatch between motor commands and sensory feedback (3, 4). The brain's continued reception of signals from nerves that once innervated the amputated limb, combined with its attempt to remap lost sensory input, may contribute significantly to the persistence of these painful sensations (5, 6).

The prevalence of PLP is estimated to be between 60% and 80% among amputees, presenting a significant clinical challenge due to its impact on the quality of life and rehabilitation outcomes (7). Conventional management of PLP predominantly involves pharmacological approaches, including analgesics, anticonvulsants, and antidepressants, which target the modulation of pain pathways. However, these treatments often provide only partial relief and are associated with adverse effects, underscoring the need for effective, non-pharmacological alternatives (8, 9). Among these, mirror therapy (MT) and mental imagery (MI) have gained considerable attention as promising rehabilitative strategies. Mirror therapy, pioneered by Dr. Vilayanur S. Ramachandran, utilizes a mirror to reflect the intact limb, creating the illusion of the presence and movement of the amputated limb. This visual feedback helps the brain reconcile the sensory-motor mismatch, facilitating pain relief through neuroplasticity (10). Studies have demonstrated the efficacy of MT in reducing PLP by leveraging the brain's capacity to reorganize itself in response to sensory inputs, thus promoting motor rehabilitation and alleviating pain (11).

Mental imagery, also referred to as motor imagery or visualization, involves patients mentally simulating movements and sensations of the amputated limb without physical execution. This method activates similar neural pathways as actual movement, potentially aiding in cortical reorganization and pain reduction (12). MI is advantageous as it does not require specific equipment, making it

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accessible and adaptable across various settings. By integrating MT and MI, there is potential to capitalize on their individual benefits, providing a complementary approach to managing PLP. MT offers tangible visual feedback that can reprogram dysfunctional neural circuits associated with the phantom limb, while MI allows for flexible application across different contexts, enhancing the overall pain management process (13, 14).

Recent assessments underscore the growing number of amputees worldwide, highlighting the importance of developing novel rehabilitation strategies that address the persistent challenges faced by this population. Understanding the neurophysiological changes following lower limb amputation is crucial in guiding the development of effective treatments. For instance, mirror therapy leverages visual feedback to modulate the brain's perception of the amputated limb, which has shown efficacy in reducing PLP across numerous studies. Conversely, MI utilizes the brain's inherent ability to simulate sensory experiences, thereby providing a non-invasive approach to pain management. Both therapies operate on the principles of neuroplasticity, aiming to reconfigure the brain's response to the absence of the limb (15, 16). As such, exploring the combined use of MT and MI could offer significant improvements in the management of PLP, potentially reducing reliance on pharmacological interventions and enhancing patients' rehabilitation outcomes (17).

MATERIAL AND METHODS

The study was conducted as a randomized clinical trial to compare the efficacy of mirror therapy versus mental imagery in reducing phantom limb pain (PLP) among patients with above-knee amputations. The research took place at Hamid Latif Hospital and Azra Naheed Teaching Hospital in Lahore, spanning from February 2023 to July 2024. Participants were selected using a non-probability convenience sampling technique, including both male and female individuals aged 12 to 75 years who had undergone a unilateral above-knee amputation at least six months prior to the study and had been experiencing phantom limb pain for at least three months. Exclusion criteria included individuals with a history of neurological conditions that could impair recovery or participation, such as uncontrolled diabetes, stroke, spinal cord injury, or brain damage, as well as conditions affecting pain perception or motor function. Pregnant or nursing women were also excluded from the study.

Participants were randomly assigned into two groups: Group A received mirror therapy, while Group B underwent a mental imagery intervention. Mirror therapy involved sessions where participants were seated in front of a mirror, allowing the reflection of their intact limb to create the illusion of the presence of the amputated limb. This visual feedback was intended to facilitate the reorganization of the brain's sensory and motor pathways, aiming to reduce PLP. Each session lasted thirty minutes and was conducted under the supervision of a trained therapist. In contrast, Group B participants were guided through mental imagery exercises in which they were instructed to visualize movements and sensations of the amputated limb. The mental imagery intervention focused on promoting complete, comfortable mobility and reducing pain through the mental simulation of limb movements. Sessions for Group B also lasted thirty minutes and included guided relaxation techniques to enhance the effectiveness of the mental imagery exercises.

Data collection involved the use of the Numeric Pain Rating Scale (NPRS) as the primary outcome measure to assess pain levels pre- and post-intervention. The NPRS is a reliable and valid tool for measuring pain intensity, with scores ranging from 0 (no pain) to 10 (worst imaginable pain) (17). Ethical approval for the study was obtained from the institutional review boards of both participating hospitals, and the research adhered to the principles outlined in the Declaration of Helsinki. Informed consent was obtained from all participants before enrollment in the study, ensuring that they were fully aware of the study's purpose, procedures, and potential risks.

Data analysis was performed using SPSS version 25. Descriptive statistics, including means, standard deviations, and frequency distributions, were used to summarize the demographic and clinical characteristics of the participants. Inferential statistics were applied to evaluate the differences between groups. A Mann-Whitney U test was used to compare NPRS scores between groups due to the non-parametric nature of the data. Additionally, within-group analyses were conducted using the Wilcoxon signed-rank test to assess changes in NPRS scores from pre- to post-intervention. A p-value of less than 0.05 was considered statistically significant (18). The study was conducted with strict adherence to ethical guidelines, and all data were handled confidentially to protect participant privacy. The study's design aimed to provide robust evidence on the comparative effectiveness of mirror therapy and mental imagery in managing phantom limb pain, contributing to the broader field of non-pharmacological pain management strategies for amputees.

RESULTS

The study included 24 participants aged between 12 and 75 years, with a mean age of 36.08 years (SD = 15.97). The gender distribution indicated that males constituted 66.7% (n=16) of the sample, while females represented 33.3% (n=8).

Table 1: Demographic Characteristics of Participants

Characteristic	Group A (n=12)	Group B (n=12)	Total (N=24)
Mean Age (years)	35.25	36.92	36.08
Gender (Male/Female)	8/4	8/4	16/8

Participants were evenly divided into two groups: Group A (Mirror Therapy) and Group B (Mental Imagery). The pre- and post-intervention pain scores were evaluated using the Numeric Pain Rating Scale (NPRS). The data were analyzed using the Mann-Whitney U test and Wilcoxon signed-rank test to assess differences between and within groups.

Table 2: Mann-Whitney U Test Results for Pre- and Post-Treatment NPRS Scores

Group	Mean Rank (Pre)	Median (Pre)	Mean Rank (Post)	Median (Post)	z-value	p-value
Group A	12.58	1.00	9.79	1.00	-0.729	0.052
Group B	12.42	1.00	15.21	1.00	-0.729	0.052

The Mann-Whitney U test results showed no significant difference in the pre-treatment NPRS scores between Group A and Group B ($p = 0.952$), indicating comparable pain levels at baseline. However, the post-treatment NPRS scores showed a tendency towards significance ($p = 0.052$), suggesting that mirror therapy (Group A) may have been more effective than mental imagery (Group B) in reducing PLP.

Table 3: Wilcoxon Signed-Rank Test Results for Within-Group Analysis

Group	Time Point	Mean Rank	z-value	p-value
Group A	Pre-NPRS	8.33	-	0.000
	Post-NPRS	1.15	-	0.000
Group B	Pre-NPRS	8.73	-	0.000
	Post-NPRS	6.83	-	0.000

The Wilcoxon signed-rank test indicated a significant reduction in NPRS scores within both groups from pre- to post-treatment ($p = 0.000$ for both groups). Group A demonstrated a more pronounced decrease in pain scores compared to Group B, supporting the potential efficacy of mirror therapy in managing phantom limb pain among above-knee amputees. Overall, the results highlight that both mirror therapy and mental imagery are effective in reducing phantom limb pain, with mirror therapy showing a slightly superior outcome, although further investigation is required to confirm these findings.

DISCUSSION

This study investigated the comparative efficacy of mirror therapy and mental imagery in reducing phantom limb pain (PLP) among above-knee amputees. The results demonstrated that both interventions effectively reduced PLP, with a more pronounced reduction observed in the mirror therapy group, suggesting its superior potential in managing PLP. These findings align with previous research that has highlighted the utility of mirror therapy in alleviating PLP through the modulation of neuroplasticity and sensory-motor integration (15). The visual feedback provided by mirror therapy creates an illusion of the presence of the amputated limb, which helps to resolve the sensory-motor incongruence that is thought to underlie PLP, thus facilitating pain reduction (15, 16).

The study by Mallik et al. (2020) also reported significant pain reduction in the mirror therapy group compared to a control group, with sustained effects observed over a 12-week follow-up period, indicating the long-term benefits of this approach (18). Similarly, Barbin et al. (2016) found that mirror therapy significantly lowered pain intensity in individuals with upper and lower limb amputations, supporting the current findings that mirror therapy could offer substantial pain relief for PLP patients (15). In contrast, mental imagery, although beneficial, may lack the tangible visual feedback necessary to fully engage the neural mechanisms that underlie pain reduction, as it relies solely on the patient's ability to visualize the movements and sensations of the missing limb. Despite this, mental imagery remains a valuable intervention due to its accessibility and ease of application without the need for specific equipment, making it a feasible option in settings where resources are limited (17).

The current study's strengths include the use of a randomized clinical trial design, which minimizes bias and enhances the reliability of the findings. Furthermore, the study's inclusion of both male and female participants across a wide age range enhances the generalizability of the results to a broader amputee population. However, the study also had several limitations. The small sample size may have limited the power to detect statistically significant differences between the groups, particularly in the post-treatment analysis. Future studies with larger sample sizes are recommended to validate these findings and to explore the long-term effects of both interventions on PLP. Additionally, the non-probability sampling technique used in this study could introduce selection bias, potentially limiting the generalizability of the results. A randomized controlled trial with a larger and more diverse sample could provide more robust evidence regarding the comparative efficacy of these interventions.

The study's reliance on self-reported pain measures, such as the Numeric Pain Rating Scale (NPRS), is another limitation, as it may be subject to participant bias. Objective measures of pain and function, such as functional MRI or neurophysiological assessments, could provide a more comprehensive understanding of the underlying mechanisms through which these therapies exert their effects. Moreover, the study did not account for potential confounding factors, such as participants' prior experience with pain management techniques, psychological factors, or the presence of other comorbidities, which could influence the outcomes. Future research should consider these variables to better isolate the effects of mirror therapy and mental imagery on PLP.

CONCLUSION

In conclusion, this study provided evidence that both mirror therapy and mental imagery are effective, non-pharmacological interventions for reducing PLP in above-knee amputees, with mirror therapy showing a slightly greater effect. Given the chronic nature of PLP and the limitations of pharmacological treatments, these findings underscore the importance of incorporating non-invasive therapies such as mirror therapy into standard rehabilitation protocols for amputees. Further research is needed to explore the mechanisms of action, optimize intervention protocols, and assess the long-term sustainability of these therapeutic effects. Enhanced understanding of how these interventions can be tailored to individual patient needs could significantly improve pain management and quality of life for individuals experiencing phantom limb pain (19).

REFERENCES

1. Bekrater-Bodmann R, Reinhard I, Diers M, Fuchs X, Flor H. Relationship of Prosthesis Ownership and Phantom Limb Pain: Results of a Survey in 2383 Limb Amputees. Pain. 2021;162(2):630-40.
2. Xie HM, Zhang KX, Wang S, Wang N, Wang N, Li X, et al. Effectiveness of Mirror Therapy for Phantom Limb Pain: A Systematic Review and Meta-Analysis. Arch Phys Med Rehabil. 2022;103(5):988-97.
3. Schober TL, Abrahamsen C. Patient Perspectives on Major Lower Limb Amputation: A Qualitative Systematic Review. Int J Orthop Trauma Nurs. 2022;46:100958.
4. Peters BR, Russo SA, West JM, Moore AM, Schulz SA. Targeted Muscle Reinnervation for the Management of Pain in the Setting of Major Limb Amputation. SAGE Open Med. 2020;8:2050312120959180.
5. Limakatso K, Corten L, Parker R. The Effects of Graded Motor Imagery and Its Components on Phantom Limb Pain and Disability in Upper and Lower Limb Amputees: A Systematic Review Protocol. Syst Rev. 2016;5:1-6.
6. Rierola-Fochs S, Merchán-Baeza JA, Minobes-Molina E. Effectiveness of Graded Motor Imagery Protocol in Phantom Limb Pain in Amputee Patients: Protocol of a Randomized Clinical Trial. PLoS One. 2022;17(8).
7. Zernitz M, Rizzello C, Rigoni M, Van de Winckel A. Case Report: Phantom Limb Pain Relief After Cognitive Multisensory Rehabilitation. Front Pain Res. 2024;5:1374141.
8. Limakatso K, Bedwell GJ, Madden VJ, Parker R. The Prevalence and Risk Factors for Phantom Limb Pain in People with Amputations: A Systematic Review and Meta-Analysis. PLoS One. 2020;15(10).
9. Jalalmanesh M, Elahi N, Kardaani MA, Goharpaie S, Maraghi E. The Effect of Movement Correction Exercises with and Without Mirror Therapy on Pain and Disability with Chronic Low Back Patients: A Randomized Control Trial. Jundishapur J Chronic Dis Care. 2024;13(3).
10. Brenner I, Jalsevac A, Woodend K. Physical Activity for the Treatment of Phantom Limb Pain.
11. Lotze M, Moseley GL. Clinical and Neurophysiological Effects of Progressive Movement Imagery Training for Pathological Pain. J Pain. 2022;23(9):1480-91.
12. Sugawara AT, De Pretto LR, Simis M, Fregni F, Battistella LR. Primary Motor Area Activity in Phantom Limb Imagery of Traumatic Unilateral Lower Limb Amputees with Phantom Limb Pain. Adv Rehabil Sci Pract. 2024;13:27536351241261023.
13. Mollà-Casanova S, Page Á, López-Pascual J, Inglés M, Sempere-Rubio N, Aguilar-Rodríguez M, et al. Effects of Mirror Neuron Activation Therapies on Functionality in Older Adults: Systematic Review and Meta-Analysis. Geriatr Nurs. 2024;56:115-23.
14. Akhlaghdoust M, Shakeri M, Faraji M, Khanmirzaei A. Central Nervous System Neuromodulation Techniques for Management of Phantom Limb Pain: A Review of Clinical Trials. Interv Pain Med Neuromodulation. 2023(In Press).
15. Barbin J, Seetha V, Casillas JM, Paysant J, Perennou D. The Effects of Mirror Therapy on Pain and Motor Control of Phantom Limb in Amputees: A Systematic Review. Ann Phys Rehabil Med. 2016;59(4):270-5.
16. Herrador Colmenero L, Perez Marmol JM, Martí-García C, Querol Zaldivar MdlÁ, Tapia Haro RM, Castro Sánchez AM, et al. Effectiveness of Mirror Therapy, Motor Imagery, and Virtual Feedback on Phantom Limb Pain Following Amputation: A Systematic Review. Prosthet Orthot Int. 2018;42(3):288-98.
17. Tureanu LM, Stojiljkovic L. Phantom Limb Pain. Chronic Pain Management in General and Hospital Practice. 2021:261-77.
18. McClintick A, Nilsson N. Motor Imagery: The Power of Imagination. Azusa Pacific University; 2021.
19. Alim MA, Akter A, Razzaque A, Mim AA, Alam E, Karim MR, et al. Neurodevelopmental Treatment (NDT) Approach for Improving Balance in the Hemiplegic Stroke Patient: A Comprehensive Case Study.