There is moderate evidence that mirror therapy is as effective as alternative interventions in reducing phantom limb pain in adults with unilateral amputations.

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CLINICAL SCENARIO:

Condition/Problem:

Phantom limb pain (PLP) is a painful sensation perceived by the body in a body part that no longer exists (Amputee Coalition, 2015). The pathophysiology and etiology of PLP is still not fully understood. According to Mayo Clinic (2015), magnetic resonance imaging (MRI) and positron emission tomography (PET) scans show that portions of the brain once responsible for sending signals to the missing limb are still active, contributing to PLP. It is also thought that areas of the brain and spinal cord corresponding to the missing limb are no longer receiving input and may respond by creating a pain sensation (Mayo Clinic, 2015).

Although PLP often decreases in frequency and duration 6 months post-amputation (Amputee Coalition, 2015), people who have PLP may continue to experience this phenomenon even several decades after their amputation, and some even experience an increase in pain over time (Nikolajsen et al, 1997). Psychosocial issues related to PLP have been shown to contribute to affect participation in occupations (Hanley et al., 2004).

Incidence/Prevalence:

After extensive literature review and internet search, there is variation in the report of PLP prevalence. According to our findings, 43-85% of individuals with amputation experience PLP (Amputee Coalition, 2015; Brodie et al., 2006; Darnell et al., 2012; Tilak et al., 2015).

Impact of the Problem on Occupational Performance:

PLP can contribute to a wide range of occupational performance problems. Activities of daily living (ADLs), instrumental activities of daily living (IADLs), rest and sleep, work, and social participation may all be affected secondary to the experience of PLP. Specific ADLs that may be affected include functional mobility and sexual activity. PLP may interfere with IADLs such as, care of others, driving and community mobility, home establishment and management, meal preparation and cleanup, and shopping. PLP may be too overwhelming and debilitating for the individual to carry out not only these activities, but also work-related activities. Rest and sleep may be affected as the PLP may prevent the individual from fully resting, falling asleep and/or staying asleep. Catastrophizing, which is having irrational thoughts that something is worse than it actually is, contributes to increased feelings of depression and increased pain interference in activity participation (Hanley et al., 2004), further affecting occupational performance. Social participation may also be affected as individuals may find it difficult to socialize with others with the presence of pain. It is important to note that an individual's perception of social support in regards to their PLP influences interference with activity participation and depressive symptoms. Greater social support is associated to less activity interference and greater decreases in depressive symptoms (Hanley et al., 2004).

Intervention:

Mirror therapy was an intervention method used with populations demonstrating PLP following unilateral amputation of either the upper or lower extremity, to decrease painful sensations. The

protocol of mirror therapy included placing a mirror with a slight angle in a mid-sagittal visual plane between the affected extremity and intact extremity. The client then positioned their intact extremity next to the mirror to produce an image which takes the place as the affected extremity, while the affected extremity is visually concealed from the client. Thus, the brain interpreted and perceived both extremities as being present and fully functional. Following this interpretation, the client was encouraged by the therapist to complete bilateral movements and/or exercises in the mirror.

Schedule and Treatment Context:

Upon extensive review of the literature, mirror therapy to reduce PLP in patients following unilateral amputation of the upper or lower extremity varied greatly. Mirror therapy was performed at a frequency between 4-7 days per week, for 1-8 weeks, and for 20-30 minutes per session. Total amount of mirror therapy ranged from about 1.5-21 hours. Mirror therapy has the potential to be used in virtually any contextual setting and is currently being practiced in both pediatric and geriatric populations in outpatient, inpatient, home health, acute care, day treatment, and rehabilitation occupational therapy contexts.

OT Theoretical Basis:

The occupational therapy biomechanical frame of reference supports mirror therapy for PLP because it focuses on remediation. It hypothesizes that if a deficit can be remediated then a person can more fully participate in occupations. Mirror therapy's goal is to decrease the level of PLP that the person is experiencing by making the brain perceive that the limb is still intact and not in pain. This allows for a decrease in pain symptoms and remediation of the deficit.

Science Behind the Intervention:

The exact mechanism of mirror therapy for PLP is unknown. One theory regarding the action of mirror therapy is that it allows the brain to perceive two functioning limbs rather than just one.by combining visual and proprioceptive input (Foell, 2013). Because PLP and phantom sensations are believed to be due to the brain not knowing that the limb is gone and the brain is therefore still sending it action potentials by going through the same sensory processes. Mirror therapy allows the missing limb to be perceived as being there through visual input and the brain then stops sending these actions potentials. This is believed to allow patients who perceive pain in their phantom limb, or feel that their limb is paralyzed or stuck in a position, to change that perception through visual input. Mirror therapy protocols often ask patients to move their intact limb either to the position that they feel their phantom limb is in or just to move it and imagine that their phantom limb is moving. This is hypothesized to allow the brain to send motor commands to both limbs and see through visual input that both limbs are obeying. This positive visual feedback is believed to teach the brain that the phantom limb is moving or not in pain (Ramachandran & Rogers-Ramachandran, 1995). It is possible that this decrease in pain can lead to increased functioning although no studies have been completed to test this.

Why is this Intervention Appropriate for OT:

When used as preparatory method for occupational performance, mirror therapy helps modulate and/or remediate PLP through movement of the affected extremity. Mirror therapy is appropriate for occupational therapy as defined by the Occupational Therapy Framework (3rd. ed.) to address: client factors: body functions: sensory functions: pain

In regards the International Classification of Functioning (IFC) levels, mirror therapy addresses both body functions and body structures.

FOCUSED CLINICAL QUESTION:
Is mirror therapy an effective intervention, compared to alternative interventions, in reducing phantom limb pain in adults with unilateral amputations?

SEARCH

- 8 databases searched
- 7 relevant articles located
    - 3 of these articles were critiqued due to their moderate level of strength. One study scored as high rigorous and another fell below on the Physiotherapy Evidence Database (PEDro) scale. The third study scored highly in rigor on the Quality Checklist for Quasi-experimental Designs. However, the other 4 articles were not included in the final analysis due to their lower level of strength as a result of case study design. These studies also had poor rigor, with the best scoring 2/11 on the Single Case Experimental Design (SCED) scale.
- Research supports the effectiveness of mirror therapy in reducing phantom limb pain in individuals with unilateral amputations. No studies analyzed the long-term effectiveness of mirror therapy in reducing phantom limb pain or the relationship between phantom limb pain and participation in occupations.

CLINICAL BOTTOM LINE:
There is moderate evidence that mirror therapy is as effective as alternative interventions in reducing phantom limb pain in adults with unilateral amputations.

Limitation of this CAT: This critically appraised paper (or topic) has been reviewed by occupational therapy graduate students and the course instructor.

SEARCH STRATEGY:

Table 1: Search Strategy

Databases Searched	Search Terms	Limits used	Inclusion and Exclusion Criteria
PubMed Central Journal of Medical Case Reports Biomed Central Directory of Open Access Journals (DOAJ) EBSCOhost CINAHL plus (UW) EBSCOhost Health Search Nursing Academic ClinicalKey Journals (Elsevier) OT Seeker E-journals @ Medical Journals E-journals @ Journals@Ovid	Mirror therapy Phantom limb pain Amputation Pain management	Articles from 2004-2015 "Pain" in title of article English only articles	Exclusion: • CVA/stroke • Complex regional pain syndrome • Visual impairments • Pain in unaffected extremity Inclusion: • Unilateral amputation of UE or LE • Phantom limb pain • Standard mirror therapy (not electronic)

RESULTS OF SEARCH

Table 2: Summary of Study Designs of Articles Retrieved

Level	Study Design/ Methodology of Articles Retrieved	Total Number Located	Data Base Source	Citation (Name, Year)
Level 1a	Systematic Reviews or Metanalysis of Randomized Control Trials	0		
Level 1b	Individualized Randomized Control Trials	1	*E-journals @ Wiley Online Library*	Tilak, M., Isaac, S., Fletcher, J., Vasanthan, L., Subbaiah, R., Babu, A., Bhide, R., & Tharion, G. (2015)
Level 2a	Systematic reviews of cohort studies	0		
Level 2b	Individualized cohort studies and low quality RCT's (PEDro ≤4)	1	*ClinicalKey Journals (Elsevier)*	Brodie, E., Whyte, A., & Niven, C. (2007)
Level 3a	Systematic review of case-control studies	0		
Level 3b	Case-control studies and non-randomized controlled trials (quasi experimental or clinical trials)	1	*E-journals @ Medical Journals*	Darnell, B. & Li, H. (2012)
Level 4	Case-series and poor quality cohort and case-control studies	0		
Level 5	Expert Opinion	4	E-journals @ Journals@Ovid PubMed Central EBSCOhost Health Search Nursing Academic Directory of Open Access Journals (DOAJ)	Darnell, B. (2009) Kim, S. & Kim, Y. (2012) MacLachlan, M., McDonald, D., & Walochs, J. (2004) Wilcher, D., Chernev, I., & Yan, K. (2011)

STUDIES INCLUDED

Table 3: Summary of Included Studies

	Study 1	Study 2	Study 3
Design	Randomized Control Trial	Randomized Control Trial	Quasi-experimental Repeated Measures
Level of Evidence	1b	2b	3b
Rigor Score	8/10 (PEDro)	6/10 (PEDro)	4/5 (Quality Checklist for Quasi-experimental Designs)
Population	26 adults, ages 18-60, demonstrating PLP of any duration following unilateral upper or lower limb amputation. Subjects with visual and sensory impairments, bleeding disorders, and those with bilateral amputation were excluded from the study.	80 adults, ages 20-83, with unilateral lower limb amputations and report of PLP.	40 community dwelling adults, ages 18-17, with unilateral upper or lower limb amputation and complete amputation site healing and report of pain greater than 3/10. An exclusion criterion was if the amputation was due to vascular disease from diabetes.
Intervention Investigated	Mirror therapy (n=12): four days, 20 minute treatment session per day completing simple movements while observing in the mirror, for a total of 80 minutes of treatment.	Mirror therapy (n=41): completion of 10 movements, for 10 repetitions each in 1 session using a mirror	Subjects were given a 7 minute DVD explaining how to complete mirror therapy and how to place the mirror for their specific limb. They were also given a diary and questionnaire to be filled out daily and turned in at both 4 and 8 weeks. The subjects were instructed by the DVD to complete mirror therapy once every day for 25 minutes, while doing a variety of any movements.
Comparison Intervention	Burst TENS (n=13): four day, 20 minute treatment session per day applying TENS to intact leg at the location of the amputation, for a total of 80 minutes of treatment	Concealed mirror (n=39): completion of 10 movements, for 10 repetitions each in 1 session using a concealed mirror	None
Dependent Variables	1. Phantom limb pain (PLP)	2. Phantom limb awareness (PLA) 3. Phantom limb sensation (PLS)	1. Phantom limb pain (PLP) 2. Compliance

		4. Phantom limb pain (PLP) 5. Phantom limb movement (PLM)	
Outcome Measures	1. Visual Analogue Scale (VAS) 2. Universal Pain Scale (UPS)	1. McGill Pain Questionnaire (MPQ) 2. Visual Analogue Scale (VAS)	1. Visual Analogue Scale (VAS) 2. Compliance diary
Results	1. When comparing within group pre/post test results using the VAS in both the mirror therapy and TENS groups, there was a statistically significant results, indicating both interventions were effective in reducing PLP. (Mirror therapy p= .003; TENS p=.001) 2. Within groups pre/post test results using the UPS in both mirror therapy and TENS groups also revealed statistically significant results (Mirror therapy p=.003; TENS p=.002). 3. Between group analyses demonstrated both interventions were equally effective in reducing PLP according to VAS and UPS scores.	1. PLA: No subjects reported PLA before the intervention. In the mirror therapy group, 4 subjects reported PLA after intervention and in the control group, no subjects reported PLA. 2. PLS: Significant decreases in intensity were reported by subjects in both groups following intervention [F(1,32)= 5.826; p< .05]. Power was low, thus, the visual feedback was not found to modify the quality or quantity of the phantom limb sensation. 3. PLP: Significant decrease in PLP was found in both groups with a power of 70% and 76%, therefore, no significant effects were found and mirror therapy does not reduce pain more than attempted movement alone. No subjects	1. Of the 40 participants, 9 did not initiate the therapy due to other life events or loss of contact; these subjects were excluded from the analysis. 31 subjects that did initiate the therapy had a 77.5% response rate in the first month. At baseline 87.1% of the subjects reported daily or constant phantom sensations and 90% of these subjects reported being bothered by the sensation. Of the 31 subjects at baseline, only 26 completed the two months of treatment. 2. A significant reduction in mean PLP intensity was found at 4 weeks (n=31, p=0.002) and at 8 weeks (n=26, p=0.002). The overall median percentage reduction at 8 weeks was 15.4% (four subjects reported worse pain, six reported having the same pain and 16 reported a reduction in pain).There were a variety of adverse effects (i.e. boredom, depressive symptoms)

		reported PLP post-intervention in either group. 4. PLM: A significant main effect was found [F(1, 59)= 4.408 p<0.05] with mirror therapy for movement responses (6.39 +/- 0.52) than the control group (2.97 +/- 0.52). A significant effect for movement ability was found with subjects who reported no ability to move their phantom leg producing significantly fewer movements than subjects who reported that they could move their limb prior.	reported after the therapy that were minimal. 3. Subjects with high education (> 16 years) compared with low education (<16 years) (37.5% vs 4.1%) had greater reduction in pain intensity (p=0.01). 4. They were not able to calculate if the amount of mirror therapy given had an effect on the outcome due to poor compliance with the diary.
Effect Size	n/a	n/a	n/a
Conclusion	This study found that participants in both the burst TENS and mirror therapy groups experienced significant reduction in PLP. However, there was no significant difference in the degree of reduction of PLP between the two intervention groups.	This study concluded that viewing a virtual limb while moving both the intact limb and imagining movement of the phantom limb does not reduce PLP or PLS any greater than moving both limbs without visualization. However, the process of viewing the phantom limb in the mirror therapy group did seem to help patients become more aware of their amputated limb and thus perceived greater movement of the amputated limb.	This study found that the majority of subjects would engage in short term self-treatment of mirror therapy and that subjects who begin the treatment are likely to complete it. There was also a reduction in pain with the treatment. They concluded that self-delivered mirror therapy is appropriate for some patients, especially those with greater education and motivation.

SYNTHESIS SECTION:
IMPLICATIONS FOR PRACTICE, EDUCATION and FUTURE RESEARCH

PICO:
Is mirror therapy an effective intervention, compared to alternative interventions, in reducing phantom limb pain in adults with unilateral amputations?

Operational Definition of Terms:

- Mirror therapy: Therapeutic intervention utilizing a mid-sagittally placed mirror to produce the illusion of a functionally intact limb.
- Phantom limb pain: Residual pain sensations following unilateral amputation of an extremity.
- Amputation: Surgical removal of part or the entire extremity.
- Alternative interventions: Other therapeutic interventions currently being used to treat phantom limb pain following unilateral amputation.
- Unilateral: Condition only affecting one side of the body or one limb.

Overall Conclusions:
Results: Similar Findings

- All three studies measured phantom limb pain (PLP) in either upper or lower extremity amputations using the Visual Analogue Scale (VAS). The three studies found statistically significant improvement in PLP with the use of mirror therapy.
- Mirror therapy in all three studies required the participants to move their intact limb while observing the movement in the mirror.
- None of the studies measured PLP to determine whether mirror therapy produces long-term effects in reduction of pain.
- The majority of participants in all three studies were primarily male.

Results: Differences

- The comparison treatment differed across all 3 studies and included exercise (Brodie et al., 2007), TENS (Tilak et al., 2015), and no comparison (Darnall et al., 2012).
- In two of the studies (Tilak et al., 2015, Brodie et al. 2007), participants received mirror therapy in a rehabilitation center while in the other study (Darnall et al., 2012) intervention was a home-based program.
- The amount of mirror therapy treatment varied in frequency, intensity, and duration across all 3 studies. One study group received mirror therapy one 20 minute session per day for four days (Tilak et al., 2015). Participants were instructed to perform simple movements with their intact limb. Another study group only received one day of intervention, taking as long as needed to complete 10 repetitions of 10 different exercises (Brodie, 2007). And lastly, the home-based study suggested that participants do 25 minutes of mirror therapy daily for two months, moving their intact limb gently in any manner; however, there was no formal measure to track the amount of time participants actually engaged in mirror therapy. (Darnall, 2012).
- One study (Tilak et al., 2015) used the Universal Pain Score (UPS) in addition to the VAS and found a significant reduction in pain after mirror therapy intervention.

Boundaries:

There were a total of 146 adults, ages 18-83 participating in these 3 studies. All subjects had undergone a unilateral amputation and were experiencing either phantom limb pain or awareness of their phantom limb. All of the subjects had complete amputation surgical healing. Exclusion criteria varied somewhat across the studies, but across all 3 studies, subjects with bilateral amputations or a recent amputation that was not yet healed were excluded.

Implications for Practice:

All three studies concluded that mirror therapy was an effective intervention in reducing PLP. Two of the three studies compared alternative treatment methods to mirror therapy, and the third examined the effectiveness of mirror therapy as a home-based program. The strongest study examined (Tilak et al., 2015) showed that TENS and mirror therapy were equally effective in reducing PLP. Overall, the authors from all three studies concluded that mirror therapy is an easy-to-use and cost-effective treatment to reduce PLP. Analysis of four different case studies using mirror therapy as an intervention for PLP also found similar results. However, due to the lack of strength and rigor of these studies, they were not used to draw specific conclusions for the purpose of this analysis.

Across studies, the mirror therapy programs used a basic mirror setup (mid-sagittal placement) making the amputated limb appear to be intact. Each program had the subjects move their intact limb and use mental visualization to imagine their amputated limb completing the movement. All three studies only included participants who had a unilateral amputation site that was fully healed, other exclusion criteria varied.

The least amount of intervention shown to reduce PLP was 10 repetitions of 10 exercises (specified in a previous study conducted by the same author (Brodie et al., 2003)) in one therapy session (Brodie, 2007); however, treatment times in other studies were longer. Based on these studies, no conclusions can be made on the appropriate frequency, intensity, and duration of mirror therapy necessary to reduce PLP long-term.

None of the studies related the reduction of pain from mirror therapy to increased participation in occupations, but other studies have shown that psychosocial issues associated with PLP interfere with participation in occupations (Hanley et al., 2004). Therefore, further research demonstrating the effects of mirror therapy in reducing PLP and its relation to occupational participation would provide results more applicable to occupational therapy. It could also be beneficial for future studies to examine the effectiveness of mirror therapy in reducing PLP over a longer period of time to look at the long-term effects. Also, measuring pain using parametric data would increase the statistical value of data, allowing more objective conclusions to be drawn.

Clinical Bottom Line:

There is moderate evidence that mirror therapy is as effective as alternative interventions in reducing phantom limb pain in adults with unilateral amputations.

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