PLP= phantom limb pain; PLM= phantom limb mov't; PLS= phantom limb sensation; PLA= phantom limb awareness; ↓= decrease; ↑=increase

| Title/Author/Journal /Year | Study Design/Subjects | Purpose | Intervention | Outcome Measures | Results | Conclusions | Comments |
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| **w**<br>**Murray C, Pettifer S, Bamford C et al. Disability and Rehabilitation. 2007.** | 3 case studies<br>Subj. 1: 63 yo males with left above the elbow amputation<br>Subj. 2: 60 yo male with right below the knee amputation.<br>Subj. 3: 65 yo female with left below the elbow amputation. | To provide qualitative report on a small sample to assess proof of principle for this particular IVR equipment. | Total number of sessions depended on pt's availability. Each pt was asked to perform 4 repetitive tasks while watching a full representation of their phantom limb on a screen. | The McGill Pain Questionnaire.<br>Semi-structured interviews<br>Subjects were asked to document in their pain dairies between each visit. | Subj. 1 reported ↓ in pain with the help of IVR (although short lived) & improvement in sleep pattern.<br>Subj. 2 had no consistent alteration in pain.<br>Subj. 3 reported a 4 point ↓ in pain rating. | Results from the article do not prove efficacy of IVR to reduce phantom limb pain but does demonstrate that further research needs to be done in this area. | The findings in this article alone do not demonstrate the clinical importance of this system until more research is performed. |
| **Analgesia through the look glass? A randomized controlled trial investigating the effect of viewing a 'virtual' limb upon phantom limb pain, sensation and movement**<br>**Brodie EE, Whyte A, Niven CA. European Journal of Pain. 2007.** | A randomized controlled trial.<br>80 subjects total: 41 in mirror group & 39 in control group. | To develop empirical data for the effect of moving or attempting to move a virtual limb has on phantom limb pain, sensation & mov't. | Mirror condition: subjects placed intact limb into mirror box & align phantom limb with this image.<br>Control condition: subjects aligned intact limb & phantom limb on either side of the mirror while image was obscured. Then all subjects were asked to repeat 10 mov'ts 10x. | Visual Analog Scale & McGill pain questionnaire. | **Mirror condition:**<br>***PLA***: 4/12 subj. reported PLA.<br>***PLS***: Sig. ↓ in the # of descriptors reported.<br>***PLP***: 3 reported abolition of PLP post intervention.<br>***PLS & PLP***: post-intervention, none reported PLP, 3 subjects reported PLS.<br>***PLM***: sig. ↑ found for mov't ability.<br>**Control condition**:<br>***PLA***: none reported PLA. | Mirror condition was not superior to the control condition for phantom limb pain & awareness however the mirror condition did improve phantom limb mov't compared to the control. | Results from this study were difficult to understand. It was noted from this study that simply moving the limbs is beneficial for improving phantom limb pain & awareness. |

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| | | | | | ***PLS***: sig. ↓ in #of descriptors reported. ***PLP***: 3 subjects reported the abolition of PLP. ***PLS & PLP***: Post-intervention, none reported appearance of PLP; 1 subj. reported PLS. ***PLM***: no sig. ↑ found in mov't ability. | | |
| **Increased motor control of a phantom leg in humans results from the visual feedback of a virtual leg. Brodie EE, Whyte A, Waller B. Neuroscience Letters. 2003.** | Randomized controlled study of 21 lower limb amputees. 16 males & 5 females; 11 subjects had trans-femoral amputations while 10 subjects had trans-tibial amputations. | To determine whether it is the visual feedback of a virtual limb or the repeated attempts to move the phantom limb that alters the experience of phantom leg in lower limb amputees. | Experimental condition: subjects placed intact limb into the mirror box & aligned the phantom limb to the image. Control condition: subjects placed phantom & intact limb on either side of the mirror with the image obscured. Then each subj. performed 10 LE mov'ts. | Subjects verbally described any changes experienced in their phantom limb during the intervention. Responses were recorded & scored. | Mean number of mov't responses in phantom limb for experimental group: 6.91; & for control group: 2.31. | Addition of visual feedback of a moving virtual leg in conjunction with attempted mov't of phantom leg significantly increases the ability of an amputee to move his/her leg. | No clear explanation of the results; authors did not mention how many times the interventions were implemented. |
| **Exploratory findings with virtual reality for phantom limb pain; from stump motion to agency** | Cross-sectional study of 14 subjects; 7 had an upper extremity | To develop a virtual environment system which controlled | 2 prototypes (arm & leg) were developed. Arm prototype: subjects had to | McGill pain questionnaire & visual analog scale were | 5 of the 7 subjects with UE amputations gained a sense of agency of | The use of this system allowed a returned sense of | Pts might have been biased & subj. could have experienced a |

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| **and analgesia. Cole J, Crowle S, Austwick G & Slater D. Disability & Rehabilitation. 2011.** | amputations & 7 had lower extremity amputations; all subjects experienced PLP. 9 subjects without PLP were also recruited for the study however refused to participate. | mov'ts from the proximal part of the amputated limb. Authors plan to report the results of their system based on subjects with & without phantom limb pain. | grasp an apple on the surface of a table (reaching, grasping, retrieving & replacing the apple). Leg prototype: subjects had to play with drums present in front of them perceived as if sitting on a chair (raise the leg, forward & press action of foot on pedal, release pedal, return to rest position). | both administered at an unknown frequency. | virtual arm& also experienced pain relief. Only 1/7 subjects did not experience phantom sensation during the intervention. 5/7 subjects with LE amputations gained a sense of agency of the virtual leg with 4 of them experienced reduction in pain. | agency within the virtual limb for most of the pts, accompanied by pain relief. | placebo effect secondary to the authors explaining the purpose of the study & desired outcomes to the subjects prior to the interventions. |
| **Self-delivered home-based mirror therapy for lower limb phantom pain. Darnall BD. American Journal of Physical Medicine and Rehabilitation. 2009.** | A case report of a 35 yo male with acquired left above-the-knee amputation | To provide a case report that describes the treatment of self-delivered home-based mirror therapy for lower limb phantom pain & its effectiveness. | Subj. administered mirror therapy at home. He performed LE ex's that he designed himself 3x/wk for 20-30 mins/sessions for 3 months. He also received a guide for diaphragmatic breathing & progressive muscle relaxation. | Brief Pain Inventory & Visual Analog Scale were administered pre & post treatment. | Pt reported ↓ in pain (short term). After practicing mirror therapy 20 min daily for 1 month, he reported resolution of PLP. 100% pain resolution on the VAS & Brief Pain inventory. | This case describes a successful treatment of lower limb phantom pain with mirror therapy & it demonstrates that this technique is also effective if it is self-administered in a home setting. | Potential presence of confounding variables secondary to unstructured manner of the protocol. |

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| **Training with virtual visual feedback to alleviate phantom limb pain. Mercier C and Sirigu A. Neurorehabilitation and Neural Repair. 2009** | A case series evaluating 8 male pts with PLP as a result of either above the elbow amputations or complete brachial plexus avulsions. | To assess the individual response to training with visual virtual feedback & to explore factors influencing the response to that approach. | Subjects were asked to perform a series of 10 motor tasks with 10 repetitions each. These tasks were performed with the subjects using their phantom limb with a virtual image of the missing limb on a screen. Each session lasted between 30 to 60 minutes with 2 sessions/wk for 8 wks. | Visual Analog Scale was used to rate subjects' pain before & after treatment. Subjects were also asked to complete a pain diary. | 5 out of 8 subjects reported pain reduction ≥ 30%. Avg pain relief was 38% at the end of the treatment & at the end of the 4 wk follow up. 3 subjects reported an increase in pain. | Training with virtual visual feedback alleviates PLP. The susceptibility to the visual feedback appears to be most related to the between subj. differences in the efficacy of the treatment. Also, no long term relief was observed among the subjects. | The use of different populations (those with amputations & brachial plexus lesions) makes it difficult to compare results within a specific population (for example, why does the intervention work for some amputees but not others). |
| **An Investigation into the Performance of a Virtual Mirror Box for the treatment of Phantom Limb Pain in Amputees using Augmented Reality Technology. O'Neill K, dePaor A, MacLachlan M and McDarby G. 2011** | Ambiguous study design with 18 able body subjects exposed to both mirror box therapy & augmented reality mirror. | To demonstrate the effect of augmented reality as a treatment for phantom limb pain (PLP) in pts with amputations. | Subjects were required to try mirror box therapy for 2 minutes & attempt to experience the sensation of a phantom limb | None | 88.89% of the subjects experienced PLS with mirror box. 44% reported ↑'ed effect for AR while 28% choose mirror box illusion; 28% found both methods to be equally effective. | Participants experienced greater phantom sensation while using AR compared to the mirror box. | The study utilized able body individuals; very vague descriptions; inadequate methods & no statistical analysis. |

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| **Augmenting the reality of phantom limb: three case studies using an augmented mirror box procedure** | Three case series. Subj. 1 is a 40 yo man with right transhumeral amputation; subj. 2 is 25 yo man with right forequarter amputation; subj. 3 is a 49 yo woman with a right arm amputation distal to the elbow. | Authors planned to conclude that augmented reality technology offers a promising new approach to the investigation of phantom experience & potentially to the treatment of phantom pain. | Each participant completed 2 interventions- visual feedback using standard mirror & visual feedback using augmented mirror box. A data glove was used for a 3D representation of the phantom limb on the screen. For each condition, subjects were asked to complete a series of symmetric & asymmetric arm mov'ts using both their phantom & contralateral arms. | The McGill Pain Questionnaire | Subj. 1 experienced phantom sensation with both interventions however more pronounced with standard mirror. Subj. 2 was unable to produce voluntary mov'ts in his phantom with no effect via either intervention. Subj. 3 experienced intensified phantom sensation with greater effect via AR. | Describes the potential to treat PLP by harnessing the therapeutic value of the visual feedback received from the augmented environment. However, this study only does not conclude the efficacy of this AR in alleviating PLP. | Lack of sufficient intervention sessions; contamination may have occurred since all subjects underwent 2 or 3 different conditions. |