**Introduction**

Phantom limb pain (PLP) is a neuropathic condition where individuals experience sensations of pain in a limb that has been amputated. PLP affects most amputees, often limiting their quality of life and functional rehabilitation. Despite advancements in neurorehabilitation, current treatment options are either insufficient or inaccessible for many patients. This literature review aims to explore existing solutions for PLP, evaluate key players and technologies, and identify gaps to guide future innovation.

**Method**

A systematic search was conducted across PubMed and Google Scholar, focusing on publications from the last two decades. Keywords included phantom limb pain, PLP therapy, PLP rehabilitation, PLP treatment, PLP management, PLP therapy market, mirror therapy, alleviating PLP, AR/VR-based therapy. Studies were included based on relevance to the unmet need, current treatment options, ecosystem players, and regulatory aspects**.**

**Results**

Globally, 65 million people live with limb amputations, and 1.5 million undergo amputations annually, 60% being lower limb (Okesina et al., 2024). PLP affects 50–80% of amputees, causing burning, stabbing, or cramping sensations due to maladaptive cortical reorganization and disrupted sensory pathways (Flor, 2002). It is more common in traumatic amputations and upper limb cases (Subedi & Grossberg, 2011), significantly impacting daily function and emotional well-being (Padovani et al., 2015).

Current PLP treatments vary in methods, each with differing success and limitations:

· **Pharmacological Approaches**: Analgesics and antidepressants are commonly used but often offer limited relief and have side effects. (Subedi & Grossberg, 2011).

· **Surgical Interventions**: peripheral nerve surgeries and residual limb surgical revisions (Subedi & Grossberg, 2011).

· **Prosthetic Use**: Advanced prosthetics aim to mitigate PLP by improving fit and functionality, but they are often inaccessible due to high costs (Weiss et al., 1999).

· **Mirror Therapy**: A low-cost intervention for PLP that leverages visual feedback to influence neural processing, Mirror Therapy was introduced by Ramachandran & Rogers-Ramachandran (1996). It uses a mirror to reflect the intact limb, creating the illusion of the missing limb's presence. This visual feedback activates motor and sensory brain areas, reducing the mismatch between expected and actual sensory inputs. By "retraining" the brain, it may alleviate maladaptive neural plasticity linked to PLP (Flor, 2006). While effective for some, success depends on factors like patient engagement and the ability to perceive the illusion (Herrador Colmenero et al., 2018), with unclear long-term benefits.

· **Virtual Reality (VR)**: Immersive VR environments simulate limb presence and movement, offering promising results (Rutledge et al., 2019). Yet, high costs and the need for specialized equipment limit accessibility.

· **Biofeedback and Neurofeedback**: Techniques like EMG biofeedback help patients control residual limb muscles, alleviating PLP, but typically require costly devices and professional support (Belleggia & Birbaumer, 2001).

· **Transcutaneous Electrical Nerve Stimulation (TENS)**: TENS delivers mild electrical currents to the residual limb, disrupting pain signals and promoting neural plasticity. Studies show moderate success in reducing PLP, but long-term effectiveness is uncertain. (Culp & Abdi, 2022).

Key players in the field:

· **Neuromotus™ by Integrum**: Uses AR and AI to treat phantom limb pain by decoding electrical muscle signals into movements via surface electrodes. Patients control a virtual limb in real-time, enhancing neural engagement (Ortiz-Catalan et al., 2014, 2016, 2018).

· **PhantomAR by Playbionic**: A mixed reality tool on Microsoft HoloLens 2 extends mirror therapy, allowing bi-manual tasks and interactive rehabilitation using a superimposed virtual arm (Prahm et al., 2022, 2023).

· **MyMove by 6Degrees**: Employs VR for interactive therapy, letting amputees engage in activities like soccer and music to manage phantom limb pain and improve mobility with real-time feedback (Sheba Medical Center, 2024).

**Conclusions**

This review underscores the unmet need for effective, affordable, and user-friendly PLP treatments. While technologies like VR show promise, cost and accessibility remain barriers. Current solutions often require expensive equipment or professional supervision, limiting home use and adaptability. There is a lack of simple, cost-effective options suitable for long-term rehabilitation. Future research should address these gaps.

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