

Effectiveness Of Virtual Reality On Post-Amputation Pain Lower

Extremities : *Literature Review*

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Abstract

Amputation of the lower extremities not only causes physical loss and psychological disturbance but also leads to discomfort and continuous pain sensation. Virtual reality is one of the promising alternatives as a non-pharmacological intervention in reducing pain. This method provides an experience in virtual activity that can distract patients from pain and increase relaxation. The purpose of this writing is to help identify the effectiveness of virtual reality in reducing post-amputation pain in the lower extremities. The method used in this article is a literature review method. Article searches were conducted on Scopus, Sage, Google Scholar, and ProQuest websites by entering the keywords "virtual reality pain amputation lower extremity". There were 10 articles used after being selected using these keywords. Virtual reality shows the potential effectiveness in reducing pain and improving functional outcomes in patients with lower extremity amputations. Virtual reality training oriented towards tasks also focuses on improving motor function and reducing avoidance behavior by providing a safe and controlled environment for individuals to practice and gradually increase their mobility.

Background

Every year in the United States (US), around 185,000 people undergo limb amputation. In addition to the new challenges that patients may experience in adapting to the loss of their limbs, the condition will be made worse by various post-procedure pain and sensations, including phantom limb pain (Vasantachart et al., 2022). Amputation refers to a surgical procedure carried out by removing body parts, especially the legs or extremities, for survival due to trauma, and can also be carried out as prevention of disease progression (Cheung et al., 2023). Three different pain phenomena can occur after upper extremity or lower extremity amputation, namely: phantom sensation, leg pain, and phantom limb pain (PLP). Phantom Sensations describe any feeling ascribed to a missing limb, excluding pain.

Residual Limb Pain (RLP) indicates the presence of residual limb pain, localized in the limbs, which can be extrinsic or intrinsic. This can be caused by an ill-fitting prosthesis, causing inflammation or skin ulceration. Phantom Limb Pain (PLP) characterizes the sensation of pain in a limb that has been amputated. Patients report it as burning, stinging, prickling, or pain (Eldaly et al., 2022). Statistics show that patients who experience limb loss due to amputation suffer from missing limb pain (PLP). It occurs in up to 60-80% of amputees. The pain is characterized by a feeling of twisting of the fingers, cramping, burning, and so on. This makes sufferers unable to carry out daily activities easily and comfortably. The frequency and duration

of PLP decreases after the first six months, even up to years (Adaikkammai, 2019). Apart from PLP, various other sensations can originate from a missing limb, including still feeling the presence of the missing limb, phantom sensations (such as itching and pins and needles), and kinetic and kinesthetic sensations, namely sensations of movement and position (Kulkarni et al., 2020).

Lower limb amputation can significantly impact an individual's ability to maintain stability and balance, which are essential for activities of daily living. Traditional physiotherapy interventions have been used to address these challenges, but there is a need for additional therapeutic approaches to improve outcomes. Virtual Reality therapy has shown promise in improving balance and gait in various populations, and its effectiveness as an adjunct to traditional physiotherapy in lower extremity amputee patients is currently under ongoing research (Osumi et al., 2019). Virtual Reality (VR) technology has emerged as a promising tool in the field of rehabilitation for individuals with neuromotor disabilities, including lower limb amputee patients.

VR provides an interactive experience, allowing users to enter a virtual world and interact with the environment (Rutledge et al., 2019). Virtual reality (VR) is a new technology that complements the limitations of mirror therapy. VR allows individuals to experience 3-dimensional multisensory sensations using a head-worn headset where users can interact with virtual objects. (Hali et al., 2023). The use of VR therapy in rehabilitation has several advantages, including being a cost-effective and interactive system that can give individuals the illusion of entering a virtual world, allowing them to control their movements. This technology has the potential to improve balance, gait, pain reduction, and quality of life in patients with lower extremity amputations (Ambron et al., 2021).

Methods

The method used in this writing is the literature review method to explain the application of virtual reality to post-lower extremity amputation pain. Literature searches were carried out in several international journals, including the Scopus, Sage, Google Scholar and ProQuest websites by entering the keywords "virtual reality pain amputation lower extremity".

The search for literature sources began by entering keywords and obtained 6,600 articles. The criteria for searching articles carried out were a period of 5 years from 2019 to 2023, articles in English, articles using the same method were excluded, articles that could be accessed in full text, and articles in the form of the application of virtual reality to post-lower extremity amputation pain. From these search criteria, 10 articles were taken for analysis.

Result and Discussion

The table below shows some of the latest technologies in treating pain, especially post-lower extremity amputation pain. This virtual technology has been applied in various countries in the world as an alternative to non-pharmacological treatments. These studies used various techniques, including providing a virtual reality environment and task-oriented virtual reality training. Virtual reality environments provide highly interactive experiences that allow individuals to engage in virtual activities that distract them from pain and promote relaxation. This research provides new hope in the treatment of phantom limb pain using virtual reality technology.

Table 1. Journal Summary

No	Author, Year	Place	Method	Purpose	Results
1	Ambron et al., 2021	USA	A small Clinical Trial	evaluating the effectiveness of VR game technology in reducing pain (phantom limb pain) in transtibial-lower limb amputations	As many as 6 out of 7 participants experienced a reduction in pain after gaming intervention using VR. Pain was reduced by 28% in intervention without using leg movements and reduced by 39.6% after gaming intervention using leg movements. Both succeeded in reducing the PLP.
2	Kulkarni et al., 2020	UK	A pilot study	evaluated the effectiveness of VR on phantom limb pain (PLP) in amputee patients.	There were 3 groups that emerged, namely the group whose pain decreased (the number was the majority), the group whose pain remained the same (the number was small), and the group whose pain increased.
3	Adaikka m mai et al., 2019	India	A systematic Review	Assessing the effectiveness of a VR rehabilitation approach to reduce pain in lost limbs amputee patient.	VR and virtual hands provide a better experience. Provides a comfortable virtual environment.
4	Eldaly et al., 2022	USA	A systematic Review	evaluated the effectiveness of VR and AR in reducing PLP in upper extremity and lower extremity amputee patients as well as adult patients with brachial nerve injury.	From a systematic review, studies regarding the effectiveness of virtual reality (VR) and augmented reality (AR) in managing PLP are still limited and have weak designs. Although the literature reports promising results, further high-quality randomized controlled trials are needed to develop knowledge.
5	Osumi et al., 2019	India	A parallel, open-label, randomized controlled trial	Comparing the effectiveness of Virtual Reality therapy combined with physical therapy with the effectiveness of physical therapy alone for extremity amputation pain lower.	This study presents data on the effectiveness of VRT in improving balance and gait. These findings will form the basis of a phase-II RCT. If VRT improves balance significantly, it could be the basis for further research.
6	Rutledge et al., 2019	USA	Development and Feasibility Results	Evaluate the feasibility and acceptability of the intervention and assess the benefits of VR therapy in reducing the intensity of PLP and phantom sensations as a result of first-time and repeated use of VR.	The use of VR therapy showed statistical significance in reducing the intensity and phantom sensation of PLP. These benefits are felt the first time and repeated use. Participants also rated VR therapy as satisfying and enjoyable.
7	Chung et al., 2023	China	A systematic review and meta-analysis	Assessing the intervention of X-reality in PLP. Also estimates the overall impact of pain reduction.	X-reality interventions in the form of VR, augmented reality and mixed reality show positive effects in reducing pain.

8	Hali et al., 2023	Canada	A systematic review	Concluding research on the effectiveness of VR therapy on PLP.	Across 15 studies, 14 studies showed a reduction in pain scales after one VR session or multiple VR sessions. VR therapy combined with tactile simulation provides a greater effect compared to VR therapy alone.
9	Donegan et.al., 2022	Spanyol	Narative review	identify the benefits of VR that focuses on correcting body distortions and identify the types of distortions or illusions that are more effective.	This treatment can help treat a range of painful conditions that were previously difficult to treat. However, there is still little knowledge about the optimal dosage for body illusion, there is still no explanation about whether repeated treatment can prolong the analgesic effect or not, and the minimum or optimal time for the number and duration of treatment sessions is unknown.
10	Tong et.al., 2021	Brazil	Investigating	Examining the long-term effects of a VR intervention in reducing PLP and accompanying changes in phantom limb motor imagery.	The pain scale in 5 patients decreased before and after the intervention.

Virtual Reality (VR) is a technology created so that humans can interact with environments that originate from computer simulations. In today's digital era, VR is being looked at in various aspects, including the world of health. The application of VR technology is used in educational facilities in the health sector, providing training for health workers, assisting with patient care, and as a means for carrying out rehabilitation (Azadin, 2023). The use of the VR method in Nursing Lab Learning shows an increase in psychomotor skills, communication and knowledge of nursing students which has a positive effect on students' self-confidence (Puspitaningrum et al., 2019).

Although often associated with gaming, VR is a next-generation technology that could revolutionize a number of industries. In healthcare, practitioners are looking for ways that VR can help patients and healthcare professionals achieve better outcomes. Functions to increase surgical efficiency, increase empathy, reduce pain scale, improve physical therapy, memory and cognitive and mental function.

The University of Washington conducted a study by scanning fMRI brains on brain activity in burn patients, where the results showed minimal pain because their attention was diverted by using VR. At Cedars-Sinai Hospital, VR can help reduce pain by 24% in patients suffering from acute and chronic pain. This therapy can reduce or replace pharmacological therapy (Li, Diya. 2022). VRT (Virtual Reality Treatment) is considered to have an effect on improving balance, reducing pain in amputated limbs, phantom sensations and pain, as well as improving psychosocial conditions which can improve quality of life. This therapy will provide a new foundation in improving the balance and gait of patients with lower extremity amputations. Moreover, this therapy can also be accessed by patients at home (Moorthy et al., 2019).

Experiments using "virtual reality" in rehabilitating post-amputation people suffering from PLP pain were carried out using gloves and VR headsets. Gloves were placed on intact limbs, the resulting movements were transferred to other limbs virtually, tricking the brain patients to believe that the amputated limb is still intact and functioning. This technique can be a form of therapy that can also be applied to patients with other diseases such as post-traumatic stress disorder, various types of phobias, chronic pain, and motor dysfunction (Adaikkammai, 2019).

An RCT trial was conducted to evaluate the effectiveness of VR therapy in amputee patients experiencing PLP. Participants undertake 2 stages of VR sessions, namely the first with Distractor Therapy where participants will be given VR therapy by listening to music that relaxes them without making movements. Another stage is Limb Therapy, where participants are asked to actively carry out movements on the amputated leg and are controlled virtually. In both stages, there was a reduction in pain after carrying out both stages (Ambron et al., 2021).

In an experiment involving two participants who experienced PLP and were given VR therapy in several sessions, it was reported that both participants reported a significant decrease in PLP after several sessions. Subject 1's pain assessment showed a 50% decrease from the start of session 1 to the start of session 2, while Subject 2's pain assessment showed a 67% decrease from the start of session 1 to the start of session 4. Both participants were very enthusiastic and wanted to continue the research, but they were unable to continue because several reasons, including Subject 1 being hampered by health reasons and Subject 2 being hampered by personal reasons. However, Subject 2 reported that his overall activity increased dramatically during the experiment. After two sessions, Subject 2 walked into a local grocery store wearing a lower limb prosthesis for the first time (Ambron et al., 2018).

In using Virtual, there are several limitations, including the limited sample size. The number of samples obtained was small because it only involved lower extremity amputee sufferers. The number of visits to research sites or laboratories is also an obstacle for participants. So it is necessary to consider home therapy (Ambron et al., 2021). VR therapy is useful for a short period of time in amputee patients who experience PLP complaints. Long-term effects may be seen if used for a long time and with severe pain (Kulkarni et al., 2020).

Conclusion

VR therapy provides new hope in the treatment of lower extremity amputation pain. With further development, this method could become an effective alternative in helping patients overcome the pain experienced due to amputation. The use of VR in pain management for lower extremity amputations still requires further research to determine long-term effects and optimal application. However, preliminary evidence suggests that virtual reality has potential in reducing pain and improving functional outcomes in individuals with lower limbs.

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