PALIATIA revista de ingrijiri paliative

PALIATIA journal of palliative care

Vol. 17 / No. 3 / July 2024 https://www.paliatia.eu

Virtual reality as complementary therapy, for the relief of chronic pain: efficacy and mechanisms involved

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Abstract

Introduction: Virtual reality (VR) technology, initially used for recreational purposes, has recently gained significant attention due to technical advancements for its application as a non-pharmacological complementary method in alleviating acute and chronic pain. This study explores the potential of VR to reduce moderate to severe chronic pain in patients admitted to palliative care centers and at home.

Methodology: The literature review included studies that utilized VR immersion in a controlled environment to evaluate the efficacy of this technology in alleviating chronic pain. Data collection methods consisted of subjective patient evaluations, monitoring of vital parameters, and the use of the visual analog scale to measure pain intensity before and after VR immersion. Additionally, the review quantified the effect of VR therapy at a distance from the moment of virtual immersion.

Results: The analyzed studies indicate a significant reduction in chronic pain through the use of VR. In a randomized study with 120 patients, those exposed to VR reported a reduction in pain at 48 and 72 hours after the sessions, compared to a control group. Another study on 36 children showed a significant decrease in pain during blood draw procedures through VR distraction. The beneficial effects are also supported by neurophysiological mechanisms such as the "gate control" theory and cerebral neuroplasticity.

Conclusions: VR technology is emerging as a promising method in managing chronic pain, offering a safe and effective alternative to pharmacological therapies. Studies suggest that controlled and synchronized sensory immersion can positively impact patients' quality of life, reducing pain and associated symptoms such as anxiety and depression. Future research should explore the optimal duration of VR sessions and compare the efficacy of this method with other non-pharmacological interventions.

Keywords: virtual reality, chronic pain, complementary therapy, sensory immersion, neuroplasticity, chronic pain management, non-pharmacological therapies, sensory synchronization.

Rezumat

Introducere: Tehnologia realității virtuale (VR), folosită inițial în scopuri recreative, a câștigat in ultima perioada ca urmare e dezvoltarii tehnice, o atenție deosebita pentru utilizarea drept metodă complementară non-farmacologică cu aplicatii practice in ameliorarea durerilor acute și cronice. Acest studiu explorează/analizeaza potențialul VR de a reduce durerea cronică de intensitate moderată și severă la pacienții internați în centre de îngrijiri paliative și la domiciliu.

Metodologie: Revizuirea literaturii a inclus studii care au utilizat imersia VR într-un mediu controlat pentru a evalua eficacitatea acestei tehnologii în ameliorarea durerilor cronice. Metodele de colectare a datelor au constat in evaluări subiective ale pacienților, monitorizarea parametrilor vitali și utilizarea scalei analog vizuale pentru măsurarea intensității durerii, inainte si dupa imersia VR; precum si, cuantificarea efectului terapiei VR, la distanta de momentul imersiei virtuale.

Rezultate: Studiile analizate indică o reducere semnificativă a durerii cronice prin utilizarea VR. Într-un studiu randomizat cu 120 de pacienți, cei expuși la VR au raportat o reducere a durerii la 48 și 72 de ore după sesiuni, comparativ cu un grup de control. Alt studiu pe 36 de copii a arătat o diminuare semnificativă a durerii în timpul procedurilor de recoltare a sângelui prin distragerea atenției cu VR. Efectele benefice sunt susținute și de mecanismele neurofiziologice, cum ar fi teoria "gate control" și neuroplasticitatea cerebrală.

Concluzii: Tehnologia VR se conturează ca o metodă promițătoare în gestionarea durerii cronice, oferind o alternativă sigură și eficientă la terapiile medicamentoase. Studiile sugerează că imersia senzorială controlată și sincronizată poate avea un impact pozitiv asupra calității vieții pacienților, reducând durerea și simptomele asociate, cum ar fi anxietatea și depresia. Cercetările viitoare ar trebui să exploreze durata optimă a sesiunilor VR și să compare eficacitatea acestei metode cu alte intervenții non-farmacologice.

Cuvinte cheie: realitate virtuală, durere cronică, terapie complementară, imersie senzorială, neuroplasticitate, managementul durerii cronice, terapii nonfarmacologice, sincronizare senzoriala.

Introduction

Pain, perhaps the most dreaded symptom in a man's life, already benefits (both acute and chronic pain), from a wide range of drug therapies, unfortunately some of them with quite unpleasant side effects. In a world of technology, digitization and powerful processors, are there other accessible and efficient therapeutic methods to combat acute pain and especially chronic pain? Searching the online archives, we settled on a technical method, usually used for

recreational/entertainment, virtual reality, which we will call VR (virtual reality).
We will try to elucidate, in the framework of this analysis, the potential of VR technology to relieve chronic pain of moderate/severe intensity, in patients hospitalized in specialized palliative care services. To date, it has already been demonstrated that VR technology is effective in relieving acute pain like in procedural situations, where a patient undergoes invasive maneuvers, such as endoscopic functional explorations, induction of anesthesia or dressing changes in the burn patient. We will try to elucidate, the efficacy of this technology applied to chronic pain patients.
VR virtual reality is a fairly recently developed technology, which consists in using special eyeglasses that transpose the user into a three-dimensional (3D) environment, computer-generated. Over time, this technology has also proven its usefulness in the field of health care in the form of non-pharmacological treatment methods but also as an adjuvant method in medical education. In the first phase, VR technology was used for simulation purposes to learn practical skills or for distance learning; later it was discovered that it could be useful for alleviating medical problems of a physical or psychological nature.
Virtual reality can be defined as a computer-generated virtual world (image and sound), but it can be influenced/modified by the interaction of the person experiencing this (artificial) world. [1] Virtual reality differs from "augmented reality", which is another form of technology, that consists of superimposing digital information over the real world; whereas, VR suppresses information from the real world and facilitates interaction with a virtual, simulated world digitally. Thus, computer-simulated reality can be delivered in a non-immersive form (projecting information on a digital screen or wall), or in an immersive form, when the information is projected more realistically, with the help of specially designed digital glasses
Virtual reality in the medical field [1] was initially implemented for educational purposes, such as the acquisition of practical surgical skills, the study of patient examination, the study of anatomy of the human body, learning invasive maneuvers, learning resuscitation algorithms or learning communication skills in dealing with patients suffering from neurological disorders.
VR has also been used for therapeutic purposes, when it was intended to distract the attention of some patients undergoing painful medical maneuvers to reduce stress symptoms (psychotherapy) or for neuromotor rehabilitation
Clinical practice has demonstrated that VR can be a method of distraction when the patient is undergoing painful medical procedures (e.g. dressing changes), or that it can be used as a non-pharmacological method to relieve chronic pain; a number of results from clinical trials indicate that VR may be an alternative for relieving chronic pain. [2]
In a randomized trial involving 120 adults hospitalized on orthopedic and internal medicine wards, presenting with pain higher than 3/10 VAS, those who were benefited from the VR immersion experience, showed significant pain relief at 48 and 72 after immersion compared to those who only watched certain television health-related programs. The effect of VR therapy was all the more effective, as the underlying pain was more severe VAS 7/10. [3]
In another clinical study, it was demonstrated that in a group of 36 children, where blood samples were taken while watching VR games, the pain level was significantly lower, compared to 21 children who did not benefit from VR exposure. [4]

The utility of vr in palliative care practice

VR technology has already proven to be effective in acute pain relief, and we anticipate that by extending the sensory experience, the success rate in relieving chronic pain could be improved. Analyzing previous studies carried out in different medical care centers palliative care centers, we can state that VR technology is emerging as a promising method for relieving chronic pain, in patients hospitalized in these care centers, but also in outpatient or at home.
Many patients suffer from chronic pain, often inadequately treated, as opioid abuse increases, the need for safe alternatives is emerging. VR has arisen as an effective adjunct to pain, even for high levels of pain. While there is evidence supporting the efficacy of VR in acute pain, its use in chronic pain remains unexplored. Unfortunately, the complexity mechanisms of chronic pain may challenge the efficacy of VR.
In a study conducted in Knoxville, Tennessee [5], participants were recruited on a voluntary basis; the age limit of participants were at least 18 years of age, with no visual or hearing impairment (which would which would have made VR exposure impossible or difficult); participants were registered as patients of the outpatient pain management clinic, were psychologically assessed and received information on how the research was conducted (VR exposure).
VR exposure was performed immediately after signing the informed consent. To assess the intensity of pain, a numeric rating scale was used, numbered from 0 to 10 (zero = no pain; 10 = the most intense pain experienced by the patient). This method proved to be a reliable way of assessing pain intensity, easy to apply and with a high degree of receptivity among patients. Basically, this study investigates the impact of a VR application, "Cool!" on chronic pain. In the investigation, 30 participants with different forms of chronic pain were exposed to a five-minute session, using the Cool! app; as mentioned, patients were rating pain intensity using a visual analog scale from 0 to 10 before, during and after the VR session. Pain decreased by 33% after the session and by 60% during the session, both statistically significant($p<0.001$). Ten participants reported complete pain relief during session. The VR experience provided significant pain relief without side effects.
In conclusion, a single VR session significantly reduced chronic pain without side effects. Researchers have concluded that VR has potential as a non-opioid treatment for chronic pain, but requires further study. [5]
A systematic review and meta-analysis tracked the impact of virtual reality (VR) use in chronic pain management. The authors examined 41 studies to identify the effects of VR on pain, functioning, mobility, functional ability, functional capacity, psychological outcomes and quality of life in patients with chronic pain. The results show that VR can significantly reduce pain and significant improvements in functioning. The findings suggest that VR could be a promising intervention in the treatment of chronic pain and could become a complementary therapeutic option for these patients. [7]

Scientific background

"The Gate Control Theory Of Pain"

The Gate Control Theory of Pain refers to the spinal "mechanism“ by which the pain stimulus can be transmitted for cortical processing, thus increasing the perception of pain, or by which the painful stimulus ; alternatively the painful stimulus

can be attenuated (at the medullary level), thereby limiting the intensity of pain perception. In other words, open or closed, this neuronal "gate" facilitates or restricts the pain signal.
In practice, a painful stimulus can be "neutralized" by the simultaneous application of a non-painful stimulus that helps activate the spinal gate control mechanism, resulting in reduced pain intensity.
The neural structures involved in gate control are located in the spinal dorsal horns (gray matter), and are represented by an intercalary neuronal network that synapses with neurons of the pain conduction pathways. Activation of these interneurons in the substantia gelatinosa by painless stimuli, will lead to an inhibitory response, implicitly leading to the "closure of the gate" and the absence of pain (myelinic fibers A beta); when pain is transmitted through A delta or C fibers, an excitatory neuronal response is obtained, implicitly the perception of pain with different degrees of intensity.
Activation of fast, large diameter neuronal fibers (A.beta) can help to modulate (reduce) or sometimes even inhibit neuronal transmission through small diameter (amyelinated) A.delta or C fibers. Endorphins/serotonin released at the synaptic cleft on descending neuronal pathways help modulate pain intensity by activating these " gateway" mechanisms.
"Brain Neuroplasticity" is a neurological evolutionary process that summarizes a series of structural and functional adaptive neuronal changes. Basically, it's the ability of the nervous system to modify its activity in response to the persistence of intrinsic/extrinsic stimuli, through the appearance of structural and functional (connectivity) reorganizations, as happens in the brain after traumatic brain injury (stroke, traumatic brain injury).
Neuroplasticity: "the ability of the nervous system to change it's activity, in response to intrinsic or extrinsic stimuli by reorganizing it's structure, functions or connections"; these neuronal modifications can be beneficial (restoration of function after trauma), neutral (no changes) or pathological (e.g: consequences of stroke/traumatic injury).
Neuroplasticity involves two distinct processes; we are talking about neuronal regeneration and/or functional reorganization of nervous system. Neuronal regeneration is a complex and lengthy process that has not yet been completely elucidated in specialized literature and involves three evolutionary phases: first 48 hours after onset of neuronal injury (destruction of neurons, damage to conduction pathways), when the brain accesses alternative (secondary) neuronal pathways in order to maintain its functionality; the following phase weeks, when neural support systems are recruited and activated
Chronic pain involves changes in neuronal function, either directly, through neuronal destruction, or indirectly through neuroplasticity mechanisms initiated by tissue/neuronal damage; recent studies have shown that chronic neuropathic pain is closely linked to mechanisms of neuroplasticity in response to local or distant nerve damage; it seems that this type of neuroplasticity, involved in the development and maintenance of chronic pain, is influenced/modulated by the activity of microglial cells (cells with an immune role in the central nervous system).
Glial cells, are directly involved in synaptic remodeling/modification of the circuits of transmission and transmission of pain or indirectly, by secreting neuro-mediators (including growth hormone). In as far as the sensory circuits of pain are concerned, we find neuroplastic mechanisms active at the spinal, thalamic and cortical levels. As far as we know, microglia play an essential role in modulating neuroplasticity processes after tissue injury.

Conclusion

We already know that VR technology can help relieve pain, we envision that VR immersion sessions will have a considerable impact not only on perception of pain, but also on decreasing anxiety, stress, depression; in a word, sensory synchronization with virtual reality will have a beneficial impact on the patient's suffering. Still many questions need to be answered such as: How long does the analgesic effect extend over time after a standard exposure VR of 15 minutes? What would be the optimal duration of immersion sessions, to achieve a prolonged effect? Does the analgesic effect differ depending on the pathology for which the patient is receiving palliative care? What type of pain is beneficially responsive to VR exposure? … and many more, and future studies are needed to answer them.

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