Virtual reality for pain and anxiety management in children

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Abstract

Question Pain and anxiety are common in children who need procedures such as administering vaccines or drawing blood. Recent reports have described the use of virtual reality (VR) as a method of distraction during such procedures. How does VR work in reducing pain and anxiety in pediatric patients and what are the potential uses for it?

Answer Recent studies explored using VR with pediatric patients undergoing procedures ranging from vaccinations and intravenous injections to laceration repair and dressing changes for burn wounds. Interacting with immersive VR might divert attention, leading to a slower response to incoming pain signals. Preliminary results have shown that VR is effective, either alone or in combination with standard care, in reducing the pain and anxiety patients experience compared with standard care or other distraction methods.

Virtual reality (VR) is a computer technology that creates an artificial 3-dimensional simulated environment. Virtual reality consists of a head-mounted display and a thick pair of goggles that are connected to either a computer or a cell phone. The headset has sensors that track users' head movements, creating the illusion of moving around in the virtual space. In the past 15 years, the technology, accessibility, and widespread application of VR have progressed immensely. Virtual reality technology places patients into a "virtual world," such as the underwater world in Aqua,[1] through audio and visual immersion, and encourages users to interact with this world.[2] Although originally designed for entertainment purposes, the potential use of VR in the medical field has recently been explored. Experimental trials using VR in therapy for anxiety or posttraumatic stress disorder and for coping with pain demonstrate potential for this technology.[3]

Pediatric pain and anxiety management using VR technology

Pain is a complex experience comprising sensory, cognitive, behavioural, and psychological components. Painful procedures, such as vaccinations, intravenous injections, laceration repairs, and dressing changes for burn wounds are a common part of pediatric medical treatments.[3] Painful situations during these procedures often lead to anxiety for patients, which can cause fear and greatly affect compliance with care for future procedures. Further, conditions causing chronic pain, such as sickle cell disease, might also have detrimental effects on the lives of children.

Common pediatric pharmacologic analgesia includes opioid therapy, which is known to have high tolerance and dependence.[4] Opioids also have an unfavourable safety profile in children, with side effects ranging from nausea and constipation to cognitive impairment and respiratory depression.[5]

Distraction is a common nonpharmacologic technique used by health care professionals to manage and attenuate anxiety, and possibly pain, during painful procedures in pediatric patients.[6] Both passive distraction (eg, watching television, listening to a book) and active distraction (eg, interactive toys, electronic games) have been extensively studied and cause a decrease in pain and anxiety.[6] Virtual reality might offer even more distraction, as it completely immerses the patient in another world and involves multiple senses.[7] Patients can actively or passively participate in numerous potential programs (**Table 1**).[4,5,8-14]

How VR affects pain

The theory behind VR's role in reducing pain and not only anxiety is related to the limited attentional capacity humans have. Pain requires attention, and if some of that attention can be diverted (eg, by interacting with VR), the patient will have a slower response to incoming pain signals.[8] Pain is detected by nociceptors located throughout the body that relay pain signals to the central nervous system via A-δ fibres and C-fibres.[15] Many analgesics work by interrupting the C-fibre pathway, thus disrupting

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Table 1. Virtual reality applications used in the hospital setting

VIRTUAL REALITY APPLICATION	WHAT IT IS	SOURCE	WEBSITE
SnowWorld[4,5,8-10]	Explore an icy 3-dimensional world throwing snowballs at snowmen, penguins, and woolly mammoths	HITLab, University of Washington	**www.vrpain.com**
Virtual Reality Gorilla Exhibit[11]	Visit the gorilla habitat at Zoo Atlanta	Georgia Institute for Technology	**http://people.cs.vt.edu/~bowman/papers/vrg.pdf**
Aqua[12,13]	Explore and interact with a comfortable underwater world	kindVR	**http://kindvr.com**
Bear Blast[14]	Shoot balls at animated teddy bears	appliedVR	**https://appliedvr.io/appliedvr-content**
Feeding Frenzy	Launch different types of food to hungry animals	appliedVR	**https://appliedvr.io/appliedvr-content**
Shape Your Path	Match coloured bricks while avoiding obstacles to reach a destination	appliedVR	**https://appliedvr.io/appliedvr-content**

the way humans sense pain. Virtual reality does not interrupt the pain signals but acts both directly and indirectly on pain perception and signaling through attention, emotion, concentration, memory, and other senses.[15]

A study using functional magnetic resonance imaging of healthy patients who were using VR while exposed to a painful stimulus (thermal pain stimulator on the foot) showed a greater than 50% reduction in pain-related brain activity in 5 areas of the brain.[16] A study of 9 subjects, aged 20 to 38, compared VR simulation to opioid analgesics during thermal pain stimulation, and results were measured with subjective pain reports and functional magnetic resonance imaging.[9] Virtual reality and opioid analgesics had very comparable results in terms of pain reduction, and it was found that the combination of opioids with VR resulted in significant further reduction in pain signals ($P<.01$).[9]

Applications for pain management

Studies looking at the value of VR show reductions in both acute and chronic pain in children.[6] While the magnitude of pain from vaccines is not large, it is not uncommon for parents to postpone injections for their children owing to concerns about discomfort.[17] Among 244 children 2 to 16 years of age from California receiving seasonal influenza vaccination, using VR for approximately 30 seconds before, during, and after vaccination was associated with a 45% to 74% decrease in pain experienced compared with usual care.[18] This was evaluated by a questionnaire filled out by the children, parents, and staff immediately after the vaccination was given, which assessed fear, pain, desire to use VR in the future, VR relaxation, and staff ease in administering the vaccine.[19]

Acute dressing of burns[8,20] and rehabilitation procedures[10] are painful but important to prevent infections, contractures, and decreased range of motion in burn victims. Hoffman and colleagues incorporated VR and video games in the standard treatment of patients with burns.[5,8,10,21] Eleven burn patients, who were between 9 and 40 years of age and who required inpatient hospitalization, reported a 35% to 50% decrease in perceived pain when using VR with standard pharmacologic treatment compared with pharmacologic treatment alone.[5] This was assessed by subjects reporting 3 subjective pain ratings (cognitive, affective, and sensory) on a graphic rating scale (GRS) ranging from 0 to 10, followed by 4 subjective assessment questions related to how much fun they experienced and the "realness" of the VR (also measured using GRSs ranging from 0 to 10).[5] A larger study performed with 54 children aged 6 to 19 years old who were undergoing physical therapy in the same hospital burn unit reported significant decreases in perceived pain (27% to 44%, $P<.05$) as well as increased affect ("fun") ($P<.001$).[10] These results were measured using GRS tools ranging from 0 to 100 for the same questions and provide hope that these patients will have increased compliance with treatment, which would lead to improved long-term outcomes.[10]

A research group at Benioff Children's Hospital in San Francisco, Calif, developed VR software for children with sickle cell acute pain crises (vaso-occlusive crises).[12] Among 25 children and young adults 10 to 25 years of age, there was a 16% reduction in pain intensity and a 33% reduction in pain descriptors, measured using the Adolescent Pediatric Pain Tool.[13]

A study by Gershon et al was conducted in patients with childhood cancer (leukemia, lymphoma, solid mass) receiving port access as part of their oncology treatment at an outpatient oncology unit. Fifty-nine children 7 to 19 years of age were divided into 3 groups: a control group that received standard treatment (topical anesthetic cream), a group that received non-VR distraction, and a group that received VR distraction.[11] The children's levels of anxiety and pain were noted to decrease while using VR through 3 different assessments. Pain was reported by the patients, parents,

and nurses using a visual analogue scale; pain was reported by the researchers using the Children's Hospital of Eastern Ontario Pain Scale, and they also measured the change in pulse rate during placement of the subcutaneous venous port device.[11]

Conclusion

Recent technological advances have led to considerable cost reductions for VR equipment, and several companies are selling headsets that consist of 2 lenses and a place to insert a smartphone for less than $20.[3] This has opened the door to using VR in a clinical setting, and further research will likely solidify the efficacy of VR in pain reduction in a range of medical situations.

Competing interests
None declared

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